

IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF DELAWARE

SYMBOL TECHNOLOGIES, INC.,  
a Delaware corporation, and WIRELESS  
VALLEY COMMUNICATIONS, INC.,  
a Delaware corporation,

Plaintiffs/Counterclaim Defendants,

v.

ARUBA NETWORKS, INC.,  
a Delaware corporation,

Defendant/Counterclaim Plaintiff.

C.A. No. 07-519-JJF

**JURY TRIAL DEMANDED**

**DECLARATION OF LAWRENCE BROCCINI IN SUPPORT OF  
JOINT MOTION OF SYMBOL TECHNOLOGIES, INC. AND  
WIRELESS VALLEY COMMUNICATIONS, INC. (1) TO  
STRIKE THE FIFTH, SIXTH, AND NINTH DEFENSES AND INTRODUCTION;  
AND (2) DISMISS, IN PART, COUNT SIX OF ARUBA'S COUNTERCLAIMS**

LAWRENCE BROCCINI, under penalty of perjury, declares as follows:

1. I am a member of Hogan & Hartson LLP, co-counsel for Plaintiffs and Counterclaim Defendants Symbol Technologies, Inc. ("Symbol") and Wireless Valley Communications, Inc. ("Wireless Valley") in this action. I am admitted to practice before the courts of the State of New York, and have been admitted to practice *pro hac vice* before this Court in this matter. I submit this declaration for the purposes of placing before the Court true and correct copies of documents referenced in Symbol Technologies, Inc.'s And Wireless Valley Communications, Inc.'s Memorandum Of Points And Authorities In Support Of Their Joint Motion (1) To Strike the Fifth, Sixth, And Ninth Defenses And Introduction; and (2) Dismiss, In Part, Count Six Of Aruba's Counterclaims ("Moving Memorandum"), being filed with the Court at this time.

2. Attached as Exhibit 1 is a true and correct copy of the Answer and Counterclaims of Aruba Networks, Inc., filed on or about October 17, 2007.

3. Attached as Exhibit 2 is a true and correct copy of Plaintiffs' Complaint For Patent Infringement, filed on August 27, 2007, with Exhibits.

4. Attached as Exhibit 3 is a true and correct copy of the Certificate of Correction issued by the United States Patent and Trademark Office for U.S. Patent No. 7,173,922.

5. Attached as Exhibit 4 is a true and correct copy of the Information Disclosure Statement submitted by Wireless Valley in connection with App. No. 09/668,145, which issued as U.S. Patent No. 6,973,622.

6. Attached as Exhibit 5 is a true and correct copy of sections of the Manual of Patent Examination and Procedure, Rev. 2001, referenced in the Moving Memorandum.

7. Attached as Exhibit 6 is a true and correct copy of the June 29, 2005 Information Disclosure Statement Under C.F.R. § 1.97, filed in connection with the Application of Pradeep J. Iyer, *et al.*, entitled "A System and Method for Monitoring and Enforcing Policy Within a Wireless Network" (subsequently issued Application No. 11/171,913, but not yet issued as a patent), as well as a true and correct copy of a Patent Assignment Abstract of Title, available on the United States Patent and Trademark Office website at <http://assignments.uspto.gov/assignments/q?db+pat&pub=20050254474>, reflecting assignment of that application to Aruba.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information, and belief.

This 10th day of December, 2007.

/s/ Lawrence Brocchini  
Lawrence Brocchini

**IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF DELAWARE**

**CERTIFICATE OF SERVICE**

I, David E. Moore, hereby certify that on December 10, 2007, the attached document was electronically filed with the Clerk of the Court using CM/ECF which will send notification to the registered attorney(s) of record that the document has been filed and is available for viewing and downloading.

I further certify that on December 10, 2007, I have Electronically Mailed the document to the following person(s):

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# **EXHIBIT 1**

IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF DELAWARE

SYMBOL TECHNOLOGIES, INC., a Delaware  
Corporation, and WIRELESS VALLEY  
COMMUNICATIONS, INC., a Delaware  
Corporation,

Plaintiffs and Counter-  
Defendants,

v.

ARUBA NETWORKS, INC., a Delaware  
corporation,

Defendant and Counter-  
Claimant.

C. A. No. 07-519-JJF

DEMAND FOR JURY TRIAL

ANSWER AND COUNTERCLAIMS

INTRODUCTION AND SUMMARY

Sometimes, when companies are losing in the marketplace, they sue – hoping that they can persuade jurors to overrule the verdict of the market. This lawsuit, filed by Symbol Technologies, Inc., and Wireless Valley Communications, Inc. (both wholly owned subsidiaries of global behemoth Motorola, Inc.), is that type of case.

Aruba Networks, Inc., was founded in 2002. In early 2003, it announced major advancements in wireless LAN technologies. Aruba's advancements allowed corporations and other enterprises to lock the air against intruders, enable high-speed mobile firewalls that follow users, and construct self-calibrating Wi-Fi networks. Aruba's innovations were met with widespread acclaim – and, almost immediately, Symbol's strong interest.

Recognizing the superiority of Aruba's technologies, Symbol tried to get access to them by buying Aruba. Throughout the first half of 2003, in the course of discussions initiated by Symbol, Aruba gave Symbol essentially unfettered access to Aruba's products – the way they were designed, built, tested, and made – and to Aruba's business and marketing strategies and

plans. Although Symbol was very interested in acquiring Aruba and its technologies, ultimately the parties were not able to agree on the complete terms of a transaction.

In the years since Symbol's close inspection of Aruba, Aruba has continued to receive widespread recognition as a fast-growing technology innovator. In 2003, Aruba won the prestigious Comdex Best in Show Award. In 2005, it won the Techworld.com Wireless Security Product of the Year Award. In 2007, Aruba won the Best Wireless Broadband Security Innovation Award at the Wireless Broadband Innovations Awards, as well as the Best of Interop 2007: Wireless & Mobility Category. These are just a few of the many awards it has won since its founding in 2002.

Aruba's technological innovations have paralleled its success in the marketplace. For example, according to a published report by Dell'Oro Group, Aruba's share of the enterprise wireless LAN market rose to greater than 10% in the second quarter of 2007 from roughly 5% in the same period of 2005. During the same period, Motorola's Symbol unit lost market share, and Aruba displaced Motorola/Symbol as the world's second largest enterprise wireless LAN supplier.

On the eve of Aruba's quarterly earnings announcement a month or so ago, in which Aruba announced a significant increase in revenue, Motorola's subsidiaries, Symbol and Wireless Valley, filed this lawsuit – on patents that began issuing in 2003. The next morning, coincident with Aruba's earnings release and only hours in advance of Aruba's conference call, Motorola issued a press release announcing the filing of the suit. The complaint fails to explain why the plaintiffs:

- waited for four years after Symbol's close inspection of Aruba's technology and business to sue;
- sued with no prior notice to Aruba; and
- chose to bring this lawsuit on the eve of Aruba's earnings announcement.

That explanation can be found in Aruba's success in the marketplace.

### PARTIES

1. Aruba admits that in Securities and Exchange Commission filings Motorola, Inc., has described Symbol as a wholly owned subsidiary. Aruba is without knowledge or information sufficient to form a belief as to the truth of the remaining allegations of Paragraph 1 of the Complaint and therefore denies those allegations.

2. Aruba admits that in Securities and Exchange Commission filings Motorola, Inc., has described Wireless Valley as a wholly owned subsidiary. Aruba is without knowledge or information sufficient to form a belief as to the truth of the remaining allegations of Paragraph 2 of the Complaint and therefore denies those allegations.

3. Aruba admits that it is a Delaware corporation with a principal place of business at 1322 Crossman Avenue, Sunnyvale, CA 94089-1113, and that, for purposes of this action, The Corporation Trust Company is its registered agent for service of process in Delaware. The Complaint does not make clear what plaintiffs mean in the third sentence of Paragraph 3 of the Complaint, and Aruba therefore denies those allegations.

### JURISDICTION AND VENUE

4. Aruba admits that this action purports to arise under the Patent Laws of the United States, Title 35, United States Code, but denies any wrongdoing or liability. Aruba further admits that this Court has subject matter jurisdiction over the allegations in the Complaint under 28 U.S.C. §§ 1331 and 1338(a).

5. Aruba does not dispute that for purposes of this action venue is proper in this judicial district.

6. Aruba admits that it is subject to personal jurisdiction in this judicial district because Aruba is a Delaware corporation with an agent for service of process in Delaware. Except as expressly admitted, Aruba denies the allegations of Paragraph 6 of the Complaint.

### THE ASSERTED PATENTS – DENIAL OF INFRINGEMENT

7. Aruba admits that U.S. Patent No. 7,173,922 (“the ’922 patent”), entitled “Multiple Wireless Local Area Networks Occupying Overlapping Physical Spaces,” purports to

have issued on February 6, 2007, but denies that this patent was duly and legally issued. Aruba admits that a document that purports to be a copy of the '922 patent is attached to the Complaint as Exhibit A, but Aruba lacks knowledge that it is a true and correct copy and therefore denies the remaining allegations of Paragraph 7 of the Complaint.

8. Aruba admits that U.S. Patent No. 7,173,923 ("the '923 patent"), entitled "Security In Multiple Wireless Local Area Networks," purports to have issued on February 6, 2007, but denies that this patent was duly and legally issued. Aruba admits that a document that purports to be a copy of the '923 patent is attached to the Complaint as Exhibit B, but Aruba lacks knowledge that it is a true and correct copy and therefore denies the remaining allegations of Paragraph 8 of the Complaint.

9. Aruba is without knowledge or information sufficient to form a belief as to the truth of the allegations of Paragraph 9 of the Complaint and therefore denies those allegations.

10. Aruba admits that U.S. Patent No. 6,625,454 ("the '454 patent"), entitled "Method and System for Designing or Deploying a Communications Network Which Considers Frequency Dependent Effects," purports to have issued on September 23, 2003, but denies that this patent was duly and legally issued. Aruba admits that a document that purports to be a copy of the '454 patent is attached to the Complaint as Exhibit C, but Aruba lacks knowledge that it is a true and correct copy and therefore denies the remaining allegations of Paragraph 10 of the Complaint.

11. Aruba admits that U.S. Patent No. 6,973,622 ("the '622 patent"), entitled "System and Method for Design, Tracking, Measurement, Prediction and Optimization of Data Communication Networks," purports to have issued on December 6, 2005, but denies that this patent was duly and legally issued. Aruba admits that a document that purports to be a copy of the '622 patent is attached to the Complaint as Exhibit D, but Aruba lacks knowledge that it is a true and correct copy and therefore denies the remaining allegations of Paragraph 11 of the Complaint.

12. Aruba is without knowledge or information sufficient to form a belief as to the truth of the allegations of Paragraph 12 of the Complaint and therefore denies those allegations.

**FIRST ASSERTED CLAIM – '922 PATENT**

13. Aruba incorporates its responses to the allegations of Paragraphs 1-12 of the Complaint here.

14. Aruba denies the allegations of Paragraph 14 of the Complaint.

15. Aruba denies the allegations of Paragraph 15 of the Complaint.

16. Aruba denies the allegations of Paragraph 16 of the Complaint.

17. Aruba denies the allegations of Paragraph 17 of the Complaint.

18. Aruba denies the allegations of Paragraph 18 of the Complaint.

**SECOND ASSERTED CLAIM – '923 PATENT**

19. Aruba incorporates its responses to the allegations of Paragraphs 1-12 of the Complaint here.

20. Aruba denies the allegations of Paragraph 20 of the Complaint.

21. Aruba denies the allegations of Paragraph 21 of the Complaint.

22. Aruba denies the allegations of Paragraph 22 of the Complaint.

23. Aruba denies the allegations of Paragraph 23 of the Complaint.

24. Aruba denies the allegations of Paragraph 24 of the Complaint.

**THIRD ASSERTED CLAIM – '454 PATENT**

25. Aruba incorporates its responses to the allegations of Paragraphs 1-12 of the Complaint here.

26. Aruba denies the allegations of Paragraph 26 of the Complaint.

27. Aruba denies the allegations of Paragraph 27 of the Complaint.

28. Aruba denies the allegations of Paragraph 28 of the Complaint.

29. Aruba denies the allegations of Paragraph 29 of the Complaint.

30. Aruba denies the allegations of Paragraph 30 of the Complaint.

**FOURTH ASSERTED CLAIM – '622 PATENT**

31. Aruba incorporates its responses to the allegations of Paragraphs 1-12 of the Complaint here.

32. Aruba denies the allegations of Paragraph 32 of the Complaint.

33. Aruba denies the allegations of Paragraph 33 of the Complaint.

34. Aruba denies the allegations of Paragraph 34 of the Complaint.

35. Aruba denies the allegations of Paragraph 35 of the Complaint.

36. Aruba denies the allegations of Paragraph 36 of the Complaint.

**SEPARATE DEFENSES**

37. In addition to the defenses described below, Aruba expressly reserves the right to allege additional defenses as they become known through the course of discovery.

**FIRST DEFENSE – NON-INFRINGEMENT**

38. Aruba has not infringed, directly or indirectly, any valid asserted claim of the '922, '923, '454, or '622 patents (collectively "patents-in-suit").

**SECOND DEFENSE – INVALIDITY UNDER §§ 102 AND 103**

39. Aruba is informed and believes, and on that basis alleges, that each of asserted claims of each of the patents-in-suit is invalid for failure to meet the conditions of patentability set forth in 35 U.S.C. §§ 102 and 103, because the alleged inventions thereof are anticipated by, taught by, suggested by, and/or obvious in view of the prior art, and no claim of any of the patents-in-suit can be validly construed to cover any Aruba product or method.

**THIRD DEFENSE – INVALIDITY UNDER § 112**

40. Aruba is informed and believes, and on that basis alleges, that each of the asserted claims of each of the patents-in-suit are invalid for failure to comply with 35 U.S.C. § 112.

**FOURTH DEFENSE – INVALIDITY UNDER § 101**

41. Aruba is informed and believes, and on that basis alleges, that each of the asserted process claims of each of the patents-in-suit are invalid for failure to comply with 35 U.S.C. § 101.

**FIFTH DEFENSE – EQUITABLE ESTOPPEL**

42. The relief sought by Symbol is barred in whole or in part by the doctrine of equitable estoppel.

43. Without limiting the generality of the above allegations, Symbol asserts infringement because “Aruba designs, manufactures, and sells in the United States wireless switches (which it calls mobility controllers), access points, management servers, and related software for use in connection with WLANs, as well as software for designing, planning, configuring, monitoring, managing, and optimizing WLANs.” (Complaint ¶ 3.)

44. Symbol has known this since at least early 2003, when it told Aruba that it (Symbol) wanted to purchase Aruba and spent months trying to convince Aruba to allow Symbol to purchase it. In the course of those efforts, Symbol sent senior engineers – *including the individual named as the inventor on the '922 and '923 patents-in-suit* – to Aruba to learn, in copious detail, about Aruba’s products. Those discussions lasted for several months. During them, Aruba provided Symbol with extensive access to information about Aruba’s products, the way they were designed and built, the way they worked, Aruba’s plans for manufacturing and selling them, and Aruba’s plans for future products.

45. Although Symbol was very interested in acquiring Aruba and its technologies, ultimately the parties were not able to agree on the complete terms of a transaction.

46. At the time that Symbol was trying to convince Aruba to be purchased, Symbol’s ’922 and ’923 patent applications were no longer confidential – they had been published two years earlier, in 2001. Although those Symbol patent applications were no longer confidential, at no point during Symbol’s efforts to convince Aruba did Symbol advise or suggest that if Aruba did not agree to a transaction, Symbol would later assert those pending patents against it. At no point during Symbol’s efforts to convince Aruba did Symbol advise or suggest that Symbol had already invented the technology that Aruba had. In fact, quite the contrary: Symbol was very impressed with Aruba’s technologies, and told Aruba that it (Symbol) thought those technologies to be superior to, and different from, Symbol’s.



47. Symbol's failures and omissions were particularly egregious given that the putative named inventor on those patent applications was an integral part of the senior engineering team that was handpicked by Symbol to learn about Aruba's products – the products that Symbol now says infringes the '922 and '923 patents, and have (according to Symbol) done so since 2003.

48. Symbol's failures and omissions led Aruba reasonably to infer that Symbol did not intend to enforce any patent rights, including the then-pending '922 and '923 patent applications if they issued as patents, against Aruba. As far as Aruba understood from Symbol's conduct and silence, the parties were going to go compete in the market and let the marketplace decide which technologies and businesses were superior.

49. Since its discussions with Symbol ended in 2003, Aruba has successfully continued its efforts to invest and to innovate. It has established customer relationships based on the products that it disclosed to Symbol during the discussions in 2003. It has spent tens of millions of dollars growing its business based on the products that it disclosed to Symbol in 2003. It has attracted key executive, engineering, finance, and sales personnel based on the success of the products that it disclosed to Symbol in 2003. In these and other ways, it would materially prejudice Aruba for Symbol to be allowed to proceed with its claims.

#### **SIXTH DEFENSE – LACHES**

50. The relief sought by Symbol and Wireless Valley is barred in whole or in part by the doctrine of laches. Aruba incorporates the allegations of Paragraphs 43 through 49 here.

51. Without limiting the generality of the above allegations, as noted above, Symbol and Wireless Valley assert infringement because "Aruba designs, manufactures, and sells in the United States wireless switches (which it calls mobility controllers), access points, management servers, and related software for use in connection with WLANs, as well as software for designing, planning, configuring, monitoring, managing, and optimizing WLANs." (Complaint ¶ 3.) Even leaving aside the 2003 discussions between Symbol and Aruba, Symbol and Wireless Valley have known of Aruba and its activities for years.

52. In May 2003, for example, industry press reported, in an article that quotes both Aruba and Symbol officials, that “Start-ups and old timers in the networking and wireless worlds are flocking to the wireless switching market. The list includes . . . Aruba Wireless Networks, . . . Symbol Technologies, [and others].” There are many other such press and other such examples. Accordingly, Symbol and Wireless Valley knew or reasonably should have known of the activities now alleged by Symbol and Wireless Valley to infringe the patents-in-suit long ago.

53. In fact, this is true *even according to Symbol and Wireless Valley*. In an August 2007 industry article about this lawsuit, Symbol’s current General Counsel is described as stating that “[a]ll of Aruba’s WLAN switch, site planning and radio-frequency management and monitoring products infringe the patents, *and they have since the company began selling its first products.*” Nevertheless, Symbol and Wireless Valley delayed in bringing this suit until August 2007, on patents that first started issuing in September 2003 – waiting while Aruba invested tens of millions of dollars in designing and testing its products, developing customer relationships, and building its business. Symbol’s and Wireless Valley’s delay was unreasonable, inexcusable, and prejudicial to Aruba, and Symbol’s and Wireless Valley’s claims are barred as a result.

#### **SEVENTH DEFENSE – INEQUITABLE CONDUCT ('922 AND '923 PATENTS)**

54. Aruba is informed and believes, and on that basis alleges, that individuals charged with a duty of candor on behalf of Symbol failed, with an intent to deceive, to properly disclose to the U.S. Patent and Trademark Office information material to the patentability of the '922 and '923 patents and failed to follow the requirements of the Manual of Patent Examiners Procedure necessary to have this information considered by the U.S. Patent and Trademark Office.

55. This information includes, but is not limited to, the existence of co-pending U.S. application no. 09/457,624 (the “'624 application”), filed on December 8, 1999. At the time of filing, the '624 application was purportedly owned by Proxim, Inc., and described and claimed subject matter that, to a reasonable patent examiner, would have been material to the

patentability of the '922 and '923 patents. On or before October 1, 2004, Proxim assigned its rights in the '624 application to Symbol, so Symbol had knowledge of the contents of the '624 application at least as of the date of the assignment and likely before that. Despite knowing of the highly material contents of the '624 application, individuals charged with a duty of candor on behalf of Symbol failed to disclose the existence of the '624 application to the patent examiner responsible for the examination of the applications that resulted in the '922 and '923 patents. The patent examiner responsible for those applications would have found the 624 application material because, among other things, the examiner would have then been able to determine whether to issue a provisional obviousness-type double patenting rejection.

56. In light of the above, the '922 and '923 patents are not enforceable due to inequitable conduct.

**EIGHTH DEFENSE – INEQUITABLE CONDUCT ('454 PATENT)**

57. Aruba is informed and believes, and on that basis alleges, that individuals charged with a duty of candor on behalf of Wireless Valley failed, with an intent to deceive, to properly disclose to the U.S. Patent and Trademark Office information material to the patentability of the '454 patent and failed to follow the requirements of the Manual of Patent Examiners Procedure necessary to have this information considered by the U.S. Patent and Trademark Office.

58. This information includes, but is not limited to, the following: (i) information and publications relating to SMT Plus, a software tool developed, at least in part, by Theodore Rappaport and Roger Skidmore, and licensed to over twenty entities more than one year prior to the filing date of the '454 patent; (ii) the following publications, which the named inventors and/or prosecuting patent attorneys knew were never considered by the U.S. Patent and Trademark Office due to Wireless Valley's late submission of an Information Disclosure Statement in violation of U.S. Patent and Trademark Office rules: R.P. Torres, et al., *CINDOOR: An Engineering Tool for Planning and Design of Wireless Systems in Enclosed Spaces*, IEEE Antennas and Propagation Magazine, Vol. 41, No. 4 (Aug. 1999); M. Panjwani et al., *Interactive Computation of Coverage Regions for Wireless Communication in Multifloored*

*Indoor Environments*, IEEE Journal on Selected Areas in Communications, Vol. 14, No. 3 (Apr. 1996); U.S. Patent No. 5,491,644; R. Skidmore et al., *A Comprehensive In-Building and Microcellular Wireless Communication System Design Tool*, The Bradley Department of Electrical Engineering, MPRG-TR-97-13 (Jun. 1997); U.S. Patent No. 5,987,328; Robert Morrow et al., *Getting In*, Wireless Review, Vol. 17, No. 5 (Mar. 1, 2000); (iii) S. Fortune, et al., *WISE Design of Indoor Wireless Systems: Practical Computation and Optimization*, IEEE Computational Science & Engineering, at pp. 58-68 (Spring, 1995), at pp. 58-68 (mentioned in the background section of U.S. Patent No. 7,055,107, another Rappaport and Skidmore patent filed just days before the filing date of the '454 patent by the same attorneys that filed the '454 patent); and (iv) the following additional publications authored, at least in part, by Theodore Rappaport: Theodore Rappaport et al., *Curriculum Innovation for Simulation and Design of Wireless Communications Systems*, ASEE Annual Conference Proceedings (1996); Keith Blankenship et al., *Measurements and Simulation of Radio Frequency Impulsive Noise in Hospitals and Clinics*, Proceedings of the 47th IEEE Vehicular Technology (1997); Donna Krizman et al., *Modeling and Simulation of Narrowband Phase from the Wideband Channel Impulse Response*, Proceedings of the 47th IEEE Vehicular Technology (1997); Hanif Sherali et al., *Optimal Location of Transmitters for Micro-Cellular Radio Communication System Design*, IEEE Journal on Selected Areas in Communications, Vol. 14, No. 4 (May 1996); Lynn Abbott et al., *Interactive Computation of Coverage Regions for Indoor Wireless Communication*, Proceedings of SPIE - The International Society for Optical Engineering (1995); Jorgen Andersen et al., *Propagation Measurements and Models for Wireless Communications Channels*, IEEE Communications Magazine, Vol. 33, No. 1 (Jan. 1995); M. Panjwani et al., *An Interactive System for Visualizing Wireless Communication Coverage within Buildings*, Wireless Personal Communications, Virginia Tech's 4th Symposium (June 1-3, 1994); and Theodore Rappaport, *Sponsored Research in Radio Propagation and System Design Final Report* (Sep. 26th, 1997).

59. In light of the above, the '454 patent is not enforceable due to inequitable conduct.

**NINTH DEFENSE – INEQUITABLE CONDUCT ('622 PATENT)**

60. Aruba is informed and believes, and on that basis alleges, that individuals charged with a duty of candor on behalf of Wireless Valley failed, with an intent to deceive, to properly disclose to the U.S. Patent and Trademark Office information material to the patentability of the '622 patent and failed to follow the requirements of the Manual of Patent Examining Procedure necessary to have this information considered by the U.S. Patent and Trademark Office, and made false and misleading statements to the U.S. Patent and Trademark Office during the prosecution of the '622 patent.

61. This information includes, but is not limited to, U.S. Patent No. 6,505,045 (the "'045 patent"). At the relevant time, the Manual of Patent Examining Procedure stated that "It is desirable to avoid the submission of long lists of documents if it can be avoided. Eliminate clearly irrelevant and marginally pertinent cumulative information. *If a long list is submitted, highlight those documents which have been specifically brought to applicant's attention and/or are known to be of most significance.*" Despite the highly material disclosure of the '045 patent, individuals charged with a duty of candor on behalf of Wireless Valley cited the reference by including it as reference number 98 in an Information Disclosure Statement that included a long list of many complex separate documents, all submitted at the same time, to increase the chance that the '045 patent would be overlooked by the patent examiner, and stated that the '045 patent was "only cited as constituting related art of which the applicant is aware" and specifically disclaimed that "the references are relevant or material to the claims."

62. In light of the above, the '622 patent is not enforceable due to inequitable conduct.

**TENTH DEFENSE – UNCLEAN HANDS**

63. Aruba incorporates the allegations of Paragraphs 42 through 62 here.

64. By reason of the acts alleged above, as incorporated, each of Symbol and Wireless Valley are barred from recovery for any asserted infringement of the patents-in-suit by the equitable doctrine of unclean hands.

**ELEVENTH DEFENSE – PROSECUTION HISTORY ESTOPPEL**

65. Symbol and Wireless are estopped from construing the asserted claims of the patents-in-suit to read on Symbol's products or processes by reasons of statements made to the U.S. Patent and Trademark Office during the prosecution of the applications that led to the issuance of the patents-in-suit.

**TWELFTH DEFENSE – PLAINTIFFS' FAILURE TO GIVE NOTICE**

66. To the extent Symbol and Wireless Valley seek damages for alleged infringement prior to its giving actual or constructive notice of the patents-in-suit patent to Aruba, the relief they seek is barred by 35 U.S.C. § 287.

**DEMAND FOR A JURY TRIAL**

67. Aruba requests a trial by jury on all issues so triable.

**DENIAL OF PLAINTIFFS' PRAYER FOR RELIEF**

68. Aruba denies that Symbol or Wireless Valley are entitled to an award of any relief at all or the relief sought in their prayer for relief against Aruba. Aruba has not infringed, directly, indirectly, contributorily or by inducement, literally or equivalently, willfully or otherwise, any of the asserted claims of the patents-in-suit. Symbol's and Wireless Valley's prayer should be denied its entirety and with prejudice, and Symbol and Wireless Valley should take nothing.

**COUNTERCLAIMS**

**THE PARTIES**

69. Aruba is a corporation organized under the laws of the State of Delaware with its principal place of business at 1322 Crossman Avenue, Sunnyvale, California 94089-1113. Aruba was founded in 2002 and went public in 2007. Aruba delivers an enterprise mobility

solution that enables secure access to data, voice and video applications across wireless and wireline enterprise networks. It has won many, many awards for its technology innovations.

70. According to the Complaint, Symbol is a corporation organized under the laws of the State of Delaware, with its principal place of business at One Motorola Plaza, Holtsville New York 11742-1300. According to filings with the U.S. Securities and Exchanges Commission, Symbol is a wholly-owned subsidiary of global behemoth Motorola, Inc., and was acquired by Motorola in September 2006.

71. According to the Complaint, Wireless Valley is a corporation organized under the laws of the State of Delaware with its principal place of business at 4515 Seton Center Parkway, Suite 300, Austin, Texas 78759. According to filings with the U.S. Securities and Exchanges Commission, Wireless Valley is a wholly-owned subsidiary of global behemoth Motorola, Inc., and was acquired by Motorola in December 2005.

#### **JURISDICTION AND VENUE**

72. This Court has subject-matter jurisdiction over Aruba's patent counterclaims, which arise under the patent laws of the United States, pursuant to 28 U.S.C. §§ 1331, 1338, 2201, and 2202.

73. This Court has personal jurisdiction over Symbol, at least because Symbol filed its Complaint for patent infringement in this Court, in response to which these counterclaims are filed.

74. This Court has personal jurisdiction over Wireless Valley, at least because Wireless Valley filed its Complaint for patent infringement in this Court, in response to which these counterclaims are filed.

75. Venue is established in this district pursuant to 28 U.S.C. § 1391 and 1400. Venue is also established in this Court because Symbol and Wireless Valley have consented to the propriety of venue in this Court by filing their respective claims for patent infringement in this Court, in response to which Aruba files these counterclaims.



COUNT 1

DECLARATORY JUDGMENT OF NON-INFRINGEMENT

('922 AND '923 PATENTS)

76. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

77. An actual and justiciable controversy exists between Aruba and Symbol with respect to the asserted claims of the '922 and '923 patents because Symbol has brought this action against Aruba alleging that Aruba infringes claims of the '922 and '923 patents, which allegation Aruba denies. Absent a declaration of noninfringement, Symbol will continue wrongfully to assert claims of the '922 and '923 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

78. Aruba has not infringed, and does not infringe, the asserted claims of the '922 or '923 patents, either directly or indirectly, literally or under the doctrine of equivalents, willfully, or otherwise, and Aruba is entitled to a declaration to that effect.

COUNT 2

DECLARATORY JUDGMENT OF INVALIDITY

('922 AND '923 PATENTS)

79. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

80. An actual and justiciable controversy exists between Aruba and Symbol with respect to the asserted claims of the '922 and '923 patents because Symbol has brought this action against Aruba alleging that the asserted claims of the '922 and '923 patents are valid, which allegation Aruba denies. Absent a declaration of invalidity, Symbol will continue wrongfully to assert claims of the '922 and '923 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

81. The '922 and '923 patents are invalid for failure to comply with the requirements of Title 35, United States Code, including but not limited to §§ 101, 102, 103, and/or 112, and Aruba is entitled to a declaration to that effect.



**COUNT 3**

**DECLARATORY JUDGMENT OF UNENFORCEABILITY**

**('922 AND '923 PATENTS)**

82. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

83. An actual and justiciable controversy exists between Aruba and Symbol with respect to the asserted claims of the '922 and '923 patents because Symbol has brought this action against Aruba alleging that the asserted claims of the '922 and '923 patents are enforceable, which allegation Aruba denies. Absent a declaration of unenforceability, Symbol will continue wrongfully to assert claims of the '922 and '923 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

84. As set forth above, one or more people substantively involved in the prosecution of the application leading to the '922 and '923 patents were aware of information material to the patentability of the claims of the '922 and '923 patents, but withheld that information from the U.S. Patent and Trademark Office with the intent to deceive, during the prosecution of the '922 and '923 patents.

85. In light of the above, the '922 and '923 patents are not enforceable due to inequitable conduct.

**COUNT 4**

**DECLARATORY JUDGMENT OF NON-INFRINGEMENT**

**('454 AND '622 PATENTS)**

86. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

87. An actual and justiciable controversy exists between Aruba and Wireless Valley with respect to the asserted claims of the '454 and '622 patents because Wireless Valley has brought this action against Aruba alleging that Aruba infringes claims of the '454 and '622 patents, which allegation Aruba denies. Absent a declaration of noninfringement, Wireless Valley will continue wrongfully to assert claims of the '454 and '622 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

88. Aruba has not infringed, and does not infringe, the asserted claims of the '454 and '622 patents, either directly or indirectly, literally or under the doctrine of equivalents, willfully, or otherwise, and Aruba is entitled to a declaration to that effect.

**COUNT 5**

**DECLARATORY JUDGMENT OF INVALIDITY**

**('454 AND '622 PATENTS)**

89. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

90. An actual and justiciable controversy exists between Aruba and Wireless Valley with respect to the asserted claims of the '454 and '622 patents because Wireless Valley has brought this action against Aruba alleging that the asserted claims of the '454 and '622 patents are valid, which allegation Aruba denies. Absent a declaration of invalidity, Wireless Valley will continue wrongfully to assert claims of the '454 and '622 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

91. The '454 and '622 patents are invalid for failure to comply with the requirements of Title 35, United States Code, including but not limited to §§ 101, 102, 103, and/or 112, and Aruba is entitled to a declaration to that effect.

**COUNT 6**

**DECLARATORY JUDGMENT OF UNENFORCEABILITY**

**('454 AND '622 PATENTS)**

92. Aruba incorporates Paragraphs 1 through 66 and 69 through 75 here.

93. An actual and justiciable controversy exists between Aruba and Wireless Valley with respect to the asserted claims of the '454 and '622 patents because Wireless Valley has brought this action against Aruba alleging that the asserted claims of the '454 and '622 patents are enforceable, which allegation Aruba denies. Absent a declaration of unenforceability, Wireless Valley will continue wrongfully to assert claims of the '454 and '622 patents against Aruba, and thereby cause Aruba irreparable injury and damage.

94. As set forth above, one or more people substantively involved in the prosecution of the application leading to the '454 and '622 patents were aware of information material to the patentability of the claims of the '454 and '622 patents, but withheld that information from the U.S. Patent and Trademark Office with the intent to deceive, during the prosecution of the '454 and '622 patents. In addition, with respect to the '622 patent, and as set forth above, Aruba is informed and believes, and on that basis alleges, that individuals charged with a duty of candor on behalf of Wireless Valley made false and misleading statements to the U.S. Patent and Trademark Office during the prosecution of the '622 patent.

95. In light of the above, the '454 and '622 patents are not enforceable due to inequitable conduct.

**DEMAND FOR A JURY TRIAL**

96. Aruba requests a trial by jury on all issues so triable.

**PRAYER FOR RELIEF**

WHEREFORE, Aruba prays the Court as follows:

- A. That the Court enter judgment for Aruba against each of Symbol and Wireless Valley on their Complaint;
- B. That each of Symbol and Wireless Valley take nothing by their Complaint;
- C. That the Court dismiss each of Symbol's and Wireless Valley's claims with prejudice;
- D. That the Court declare each and every asserted claim of the '922, '923, '454 and '622 patents to be (a) not infringed by Aruba, (b) invalid, and (c) unenforceable;
- E. That, under 35 U.S.C. § 285, the Court deem this to be an exceptional case based on the conduct of each of Symbol and Wireless Valley in commencing and pursuing this action, and that the Court award Aruba its "reasonable attorney fees" against each of Symbol and Wireless Valley;
- F. That the Court award Aruba its costs of suit; and

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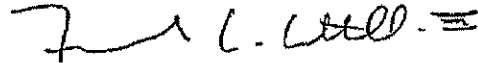
G. That the Court award Aruba such other and additional relief as this Court deems just and proper.

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Dated: October 17, 2007



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**CERTIFICATE OF SERVICE**

I hereby certify that on October 17, 2007, I electronically filed the foregoing with the Clerk of Court using CM/ECF which will send notification of such filing(s) to the following and which has also been served as noted:

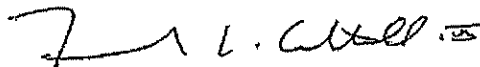
**BY HAND**

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I hereby certify that on October 17, 2007 I transmitted the document by Federal Express to the following non-registered participant:

**VIA FEDERAL EXPRESS**

Eric J. Lobenfeld  
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Lawrence Brocchini  
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# **EXHIBIT 2**

Doc # 1

IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF DELAWARE

SYMBOL TECHNOLOGIES, INC.,  
a Delaware corporation, and WIRELESS  
VALLEY COMMUNICATIONS, INC.,  
a Delaware corporation,

Plaintiffs,

v.

ARUBA NETWORKS, INC.,  
a Delaware corporation,

Defendant.

C.A. No. 07CV00519

JURY DEMANDED

**COMPLAINT FOR PATENT INFRINGEMENT**

Plaintiffs Symbol Technologies, Inc. ("Symbol") and Wireless Valley Communications, Inc. ("Wireless Valley") (collectively "Plaintiffs"), by their counsel, as and for their Complaint against Defendant Aruba Networks, Inc. ("Aruba"), allege as follows:

**PARTIES**

1. Symbol is a Delaware corporation having its principal place of business at One Motorola Plaza, Holtsville, New York 11742-1300. Symbol develops and markets innovative, high-performance products, including, *inter alia*, wireless local area networks ("WLANs") and their components, including wireless access points and wireless switches. Symbol is a wholly-owned subsidiary of Motorola Inc.

2. Wireless Valley is a Delaware corporation having its principal place of business at 4515 Seton Center Parkway, Suite 330, Austin, Texas 78759. Wireless Valley is a leading provider of software solutions for the design and management of WLANs. Wireless Valley is a wholly-owned subsidiary of Motorola, Inc.

3. Upon information and belief, Aruba is a Delaware corporation having its principal place of business at 1322 Crossman Ave., Sunnyvale, CA 94089-1113. Aruba maintains The Corporation Trust Company as its registered agent for the service of process in Delaware. Aruba designs, manufacturers, and sells in the United States wireless switches (which it calls mobility controllers), access points, management servers, and related software for use in connection with WLANs, as well as software for designing, planning, configuring, monitoring, managing, and optimizing WLANs.

#### **JURISDICTION AND VENUE**

4. This is an action arising under the patent laws of the United States, 35 U.S.C. §§ 101 *et seq.* This Court has subject matter jurisdiction pursuant to 35 U.S.C. § 271 *et seq.* and 28 U.S.C. §§ 1331 and 1338.

5. Venue is proper in this judicial district under 28 U.S.C. §§ 1391 and 1400.

6. This Court has personal jurisdiction over Aruba because Aruba is a Delaware corporation with an agent for service of process in Delaware. Upon information and belief, Aruba also places its infringing products in the stream of commerce, which stream is directed at this district.

#### **THE PATENTS**

7. Symbol is the owner by assignment of United States Letters Patent No. 7,173,922 ("the '922 Patent"), entitled "Multiple Wireless Local Area Networks Occupying Overlapping Physical Spaces." The '922 Patent duly and legally issued Feb. 6, 2007. A copy of the '922 Patent is attached to this Complaint as Exhibit A.



8. Symbol is the owner by assignment of United States Letters Patent No. 7,173,923 ("the '923 Patent"), entitled "Security In Multiple Wireless Local Area Networks." The '923 Patent duly and legally issued Feb. 6, 2007. A copy of the '923 Patent is attached to this Complaint as Exhibit B.

9. Symbol is the owner of all rights, title and interest in and to the '922 Patent and '923 Patent (collectively "the Symbol Patents") and is entitled to sue for past and future infringement of those patents.

10. Wireless Valley is the owner by assignment of United States Letters Patent No. 6,625,454 ("the '454 Patent"), entitled "Method and System for Designing or Deploying a Communications Network Which Considers Frequency Dependent Effects" The '454 Patent duly and legally issued Sept. 23, 2003. A copy of the '454 Patent is attached to this Complaint as Exhibit C.

11. Wireless Valley is the owner by assignment of United States Letters Patent No. 6,973,622 ("the '622 Patent"), entitled "System and Method for Design, Tracking, Measurement, Prediction and Optimization of Data Communications Networks." The '622 Patent duly and legally issued Dec. 6, 2005. A copy of the '622 Patent is attached to this Complaint as Exhibit D.

12. Wireless Valley is the owner of all rights, title and interest in and to the '454 Patent and '622 Patent (collectively "the Wireless Valley Patents") and is entitled to sue for past and future infringement of those patents.

**FIRST CLAIM FOR RELIEF  
(INFRINGEMENT OF THE '922 PATENT)**

13. Plaintiffs repeat and reallege the allegations in paragraphs 1-12 as if fully set forth herein.

14. Aruba has imported into the United States, made, used, sold and/or offered for sale in the United States, products covered by the '922 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '922 Patent.

15. Aruba has had actual and/or constructive notice and knowledge of the '922 Patent. The filing of this Complaint also constitutes notice in accordance with 35 U.S.C. § 287. Despite such notice, Aruba continues to import, make, use, sell and/or offer for sale in the United States products covered by the '922 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '922 Patent.

16. Aruba has infringed and/or induced the infringement of and/or contributed to the infringement of the '922 Patent by importing, making, using, offering for sale, or selling in the United States, or by intending that others import, make, use, offer for sale, or sell in the United States, products that are covered by the '922 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '922 Patent.

17. On information and belief, Aruba's infringement of the '922 Patent is willful. The continued infringement of the '922 Patent by Aruba has damaged and will continue to damage Symbol.

18. The infringement of the '922 Patent by Aruba has caused and will continue to cause Symbol irreparable harm unless preliminarily and permanently enjoined by the Court. Symbol has no adequate remedy at law.

**SECOND CLAIM FOR RELIEF  
(INFRINGEMENT OF THE '923 PATENT)**

19. Plaintiffs repeat and reallege the allegations in paragraphs 1-12 as if fully set forth herein.

20. Aruba has imported into the United States, made, used, sold and/or offered for sale in the United States, products covered by the '923 Patent.

21. Aruba has had actual and/or constructive notice and knowledge of the '923 Patent. The filing of this Complaint also constitutes notice in accordance with 35 U.S.C. § 287. Despite such notice, Aruba continues to import, make, use, sell and/or offer for sale in the United States products covered by the '923 Patent.

22. Aruba has infringed and/or induced the infringement of and/or contributed to the infringement of the '923 Patent by importing, making, using, offering for sale, or selling in the United States, or by intending that others import, make, use, offer for sale, or sell in the United States, products that are covered by the '923 Patent.

23. On information and belief, Aruba's infringement of the '923 Patent is willful. The continued infringement of the '923 Patent by Aruba has damaged and will continue to damage Symbol.

24. The infringement of the '923 Patent by Aruba has caused and will continue to cause Symbol irreparable harm unless preliminarily and permanently enjoined by the Court. Symbol has no adequate remedy at law.

**THIRD CLAIM FOR RELIEF  
(INFRINGEMENT OF THE '454 PATENT)**

25. Plaintiffs repeat and reallege the allegations in paragraphs 1-12 as if fully set forth herein.

26. Aruba has imported into the United States, made, used, sold and/or offered for sale in the United States, products covered by the '454 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '454 Patent.

27. Aruba has had actual and/or constructive notice and knowledge of the '454 Patent. The filing of this Complaint also constitutes notice in accordance with 35 U.S.C. § 287. Despite such notice, Aruba continues to import, make, use, sell and/or offer for sale in the United States products covered by the '454 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '454 Patent.

28. Aruba has infringed and/or induced the infringement of and/or contributed to the infringement one or more claims of the '454 Patent by importing, making, using, offering for sale, or selling in the United States, or by intending that others import, make, use, offer for sale, or sell in the United States, products covered by the '454 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '454 Patent.

29. On information and belief, Aruba's infringement of the '454 Patent is willful. The continued infringement of the '454 Patent by Aruba has damaged and will continue to damage Wireless Valley.

30. The infringement of the '454 Patent by Aruba has caused and will continue to cause Wireless Valley irreparable harm unless preliminarily and permanently enjoined by the Court. Wireless Valley has no adequate remedy at law.

**FOURTH CLAIM FOR RELIEF  
(INFRINGEMENT OF THE '622 PATENT)**

31. Plaintiffs repeat and reallege the allegations in paragraphs 1-12 as if fully set forth herein.

32. Aruba has imported into the United States, made, used, sold and/or offered for sale in the United States, products covered by the '622 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '622 Patent.

33. Aruba has had actual and/or constructive notice and knowledge of the '622 Patent. The filing of this Complaint also constitutes notice in accordance with 35 U.S.C. § 287. Despite such notice, Aruba continues to import, make, use, sell and/or offer for sale in the United States products covered by the '622 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '622 Patent.

34. Aruba has infringed and/or induced the infringement of and/or contributed to the infringement of one or more claims of the '622 Patent by importing, making, using, offering for sale, or selling in the United States, or by intending that others import, make, use, offer for sale, or sell in the United States, products that are covered by the '622 Patent and/or products that when used in accordance with their instructions practice the methods covered by the '622 Patent.

35. On information and belief, Aruba's infringement of the '622 Patent is willful. The continued infringement of the '622 Patent by Aruba has damaged and will continue to damage Wireless Valley.

36. The infringement of the '622 Patent by Aruba has caused and will continue to cause Wireless Valley irreparable harm unless preliminarily and permanently enjoined by the Court. Wireless Valley has no adequate remedy at law.

**WHEREFORE**, Symbol and Wireless Valley pray for a relief and judgment against Aruba as follows:

- A. Adjudging that Aruba is infringing the Symbol Patents and the Wireless Valley Patents;
- B. Adjudging that the infringement by Aruba of the Symbol Patents and the Wireless Valley Patents was willful, and that the continued infringement by Aruba of the Symbol Patents and Wireless Valley Patents is willful;
- C. Entering an order preliminarily and permanently enjoining Aruba from any further acts of infringement of the Symbol Patents and the Wireless Valley Patents;
- D. Awarding Wireless Valley damages in an amount adequate to compensate for the infringement by Aruba of the Wireless Valley Patents, but in no event less than a reasonable royalty under 35 U.S.C. § 284;
- E. Entering an order trebling any and all damages awarded to Wireless Valley by reason of the willful infringement by Aruba of the Wireless Valley Patents, pursuant to 35 U.S.C. § 284;
- F. Awarding Symbol damages in an amount adequate to compensate for the infringement by Aruba of the Symbol Patents, but in no event less than a reasonable royalty under 35 U.S.C. § 284;
- G. Entering an order trebling any and all damages awarded to by reason of the willful infringement by Aruba of the Symbol Patents, pursuant to 35 U.S.C. § 284;
- H. Entering an order awarding Symbol and Wireless Valley interest on the damages awarded and their costs pursuant to 35 U.S.C. § 284;

- I. Declaring this an exceptional case and awarding Symbol and Wireless Valley their costs, expenses, and reasonable attorneys' fees pursuant to 35 U.S.C. § 285 and all other applicable statutes, rules, and common law; and
- J. Awarding Symbol and Wireless Valley such other and further relief as the Court may deem just and proper.

**JURY DEMAND**

Symbol and Wireless Valley hereby demand trial by jury on all issues in its Complaint.

Respectfully submitted,

POTTER ANDERSON & CORROON LLP

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*Attorneys for Plaintiffs Symbol Technologies,  
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# EXHIBIT A





US007173922B2

(12) **United States Patent**  
**Beach**

(10) **Patent No.:** **US 7,173,922 B2**  
(45) **Date of Patent:** **\*Feb. 6, 2007**

(54) **MULTIPLE WIRELESS LOCAL AREA NETWORKS OCCUPYING OVERLAPPING PHYSICAL SPACES**

5,432,814 A 7/1995 Hasegawa  
5,457,557 A 10/1995 Zarem et al.

(Continued)

(75) **Inventor:** Robert Beach, Los Altos, CA (US)

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(73) **Assignee:** Symbol Technologies, Inc., Holtsville, NY (US)

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(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 704 days.

This patent is subject to a terminal disclaimer.

## OTHER PUBLICATIONS

(21) **Appl. No.:** 09/780,741

(22) **Filed:** Feb. 9, 2001

(65) **Prior Publication Data**

US 2001/0055283 A1 Dec. 27, 2001

## Related U.S. Application Data

(63) **Continuation-in-part of application No. 09/528,697, filed on Mar. 17, 2000.**

(51) **Int. Cl.**

H04Q 7/24 (2006.01)  
H04L 12/28 (2006.01)  
H04L 12/56 (2006.01)

(52) **U.S. Cl.** ..... 370/338; 370/466; 370/401

(58) **Field of Classification Search** ..... 370/338, 370/328, 333, 334, 339, 343, 400, 401, 491, 370/492, 465, 466, 469

See application file for complete search history.

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**Primary Examiner—Chirag Shah**

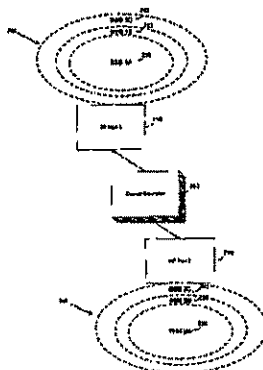
(74) **Attorney, Agent, or Firm—**Ingrassia Fisher & Lorenz, P.C.

(57)

## ABSTRACT

A wireless local area network is provided with simplified RF ports which are configured to provide lower level media access control functions. Higher level media access control functions are provided in a cell controller, which may service one or more RF ports that are capable operating with at least two wireless local area subnetworks occupying common physical space. Mobile units can also be configured with the higher level media access control functions being performed in a host processor.

45 Claims, 7 Drawing Sheets



## US 7,173,922 B2

Page 2

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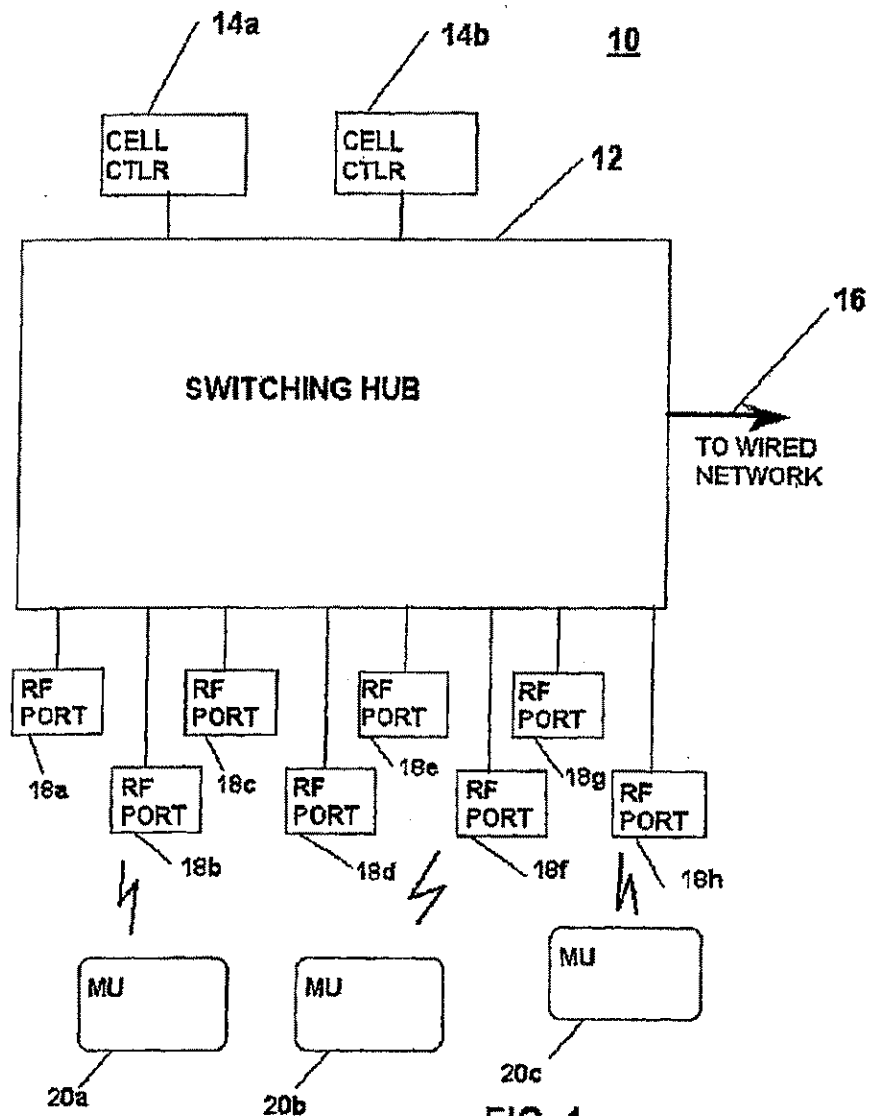


FIG. 1

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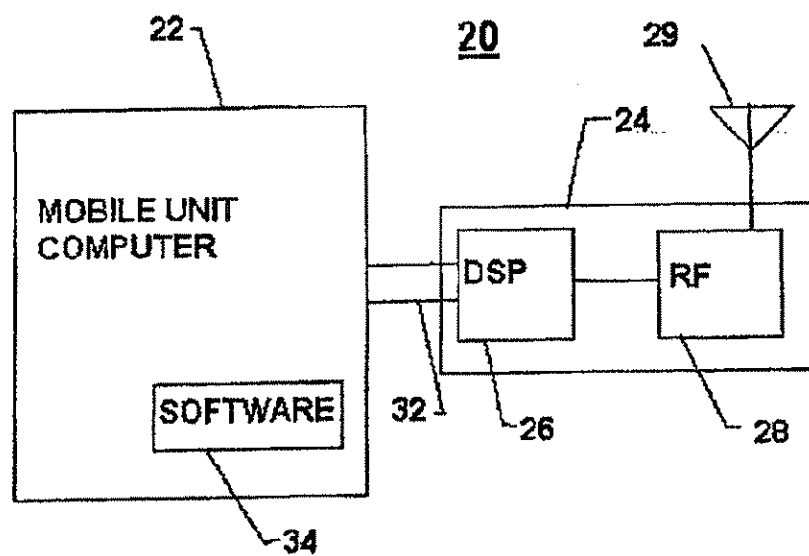


FIG. 2

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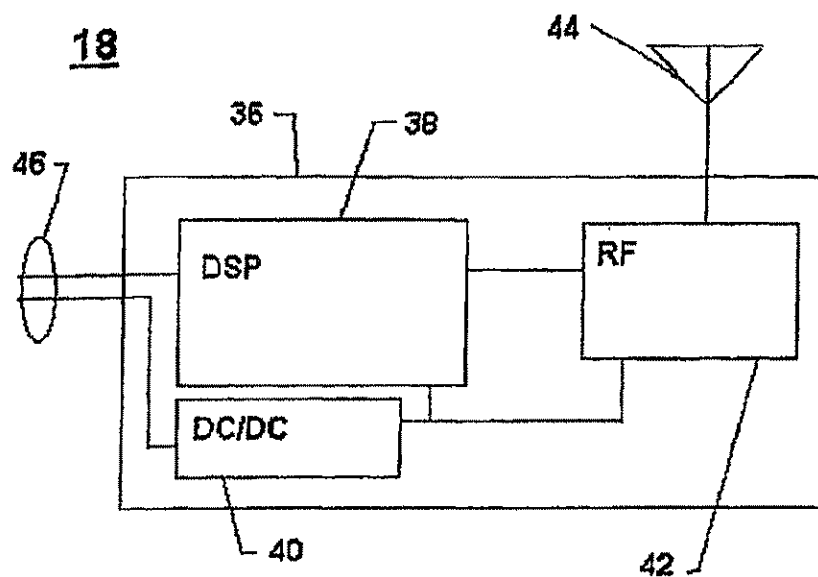


FIG.3

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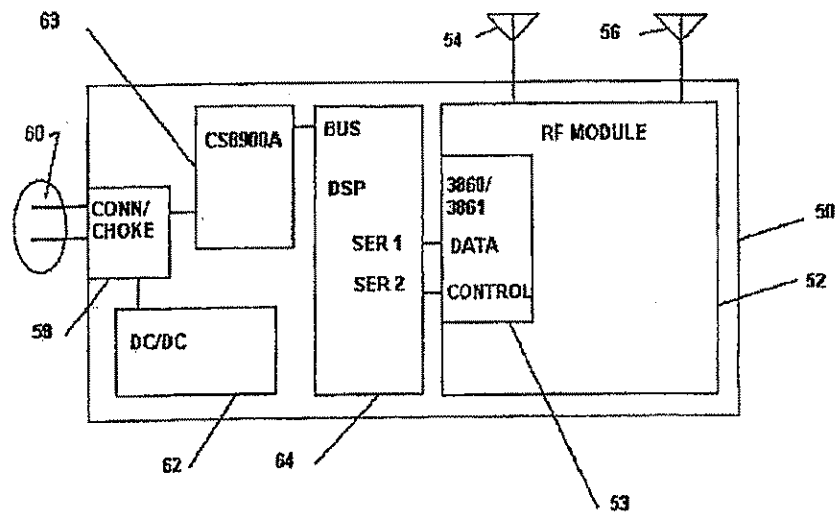


FIG. 4

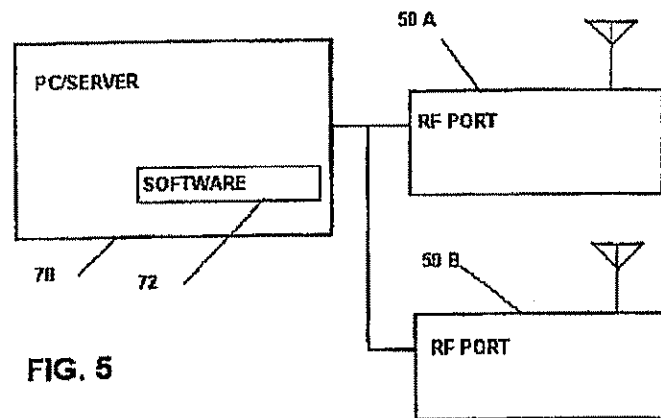


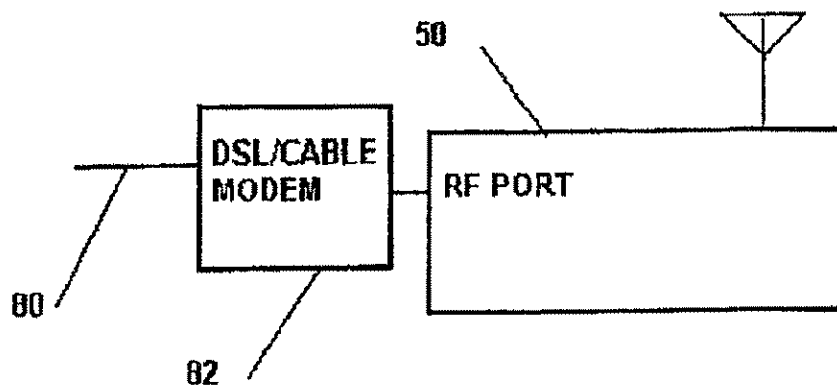
FIG. 5

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**FIG. 6**

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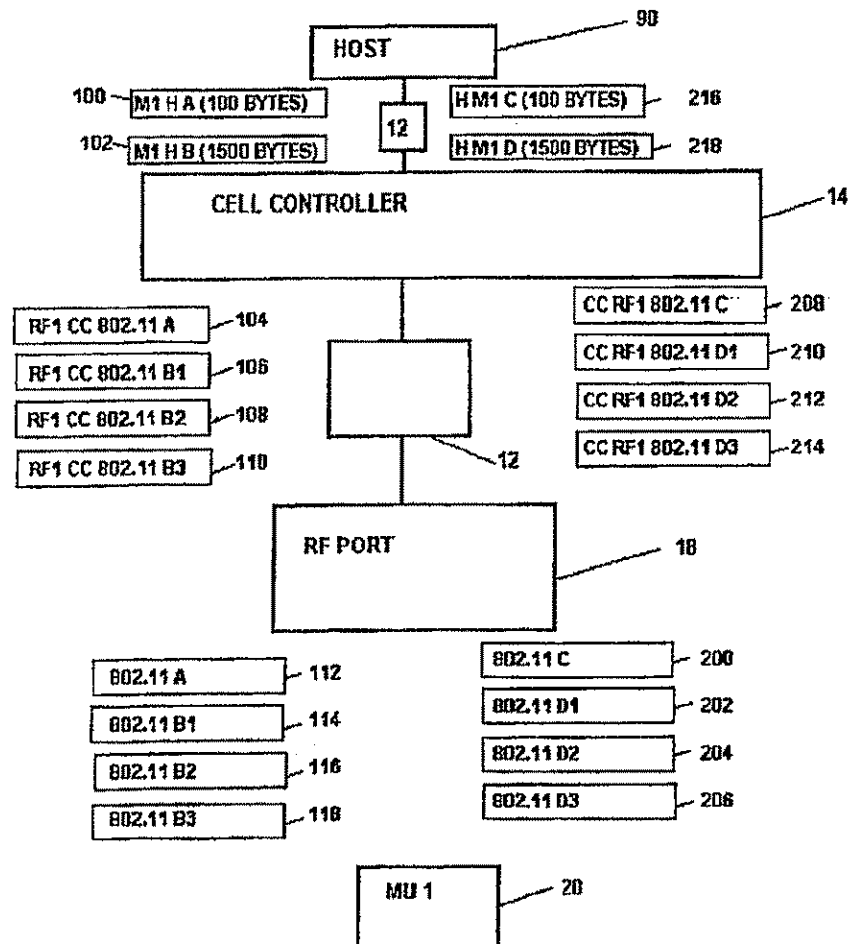


FIG. 7



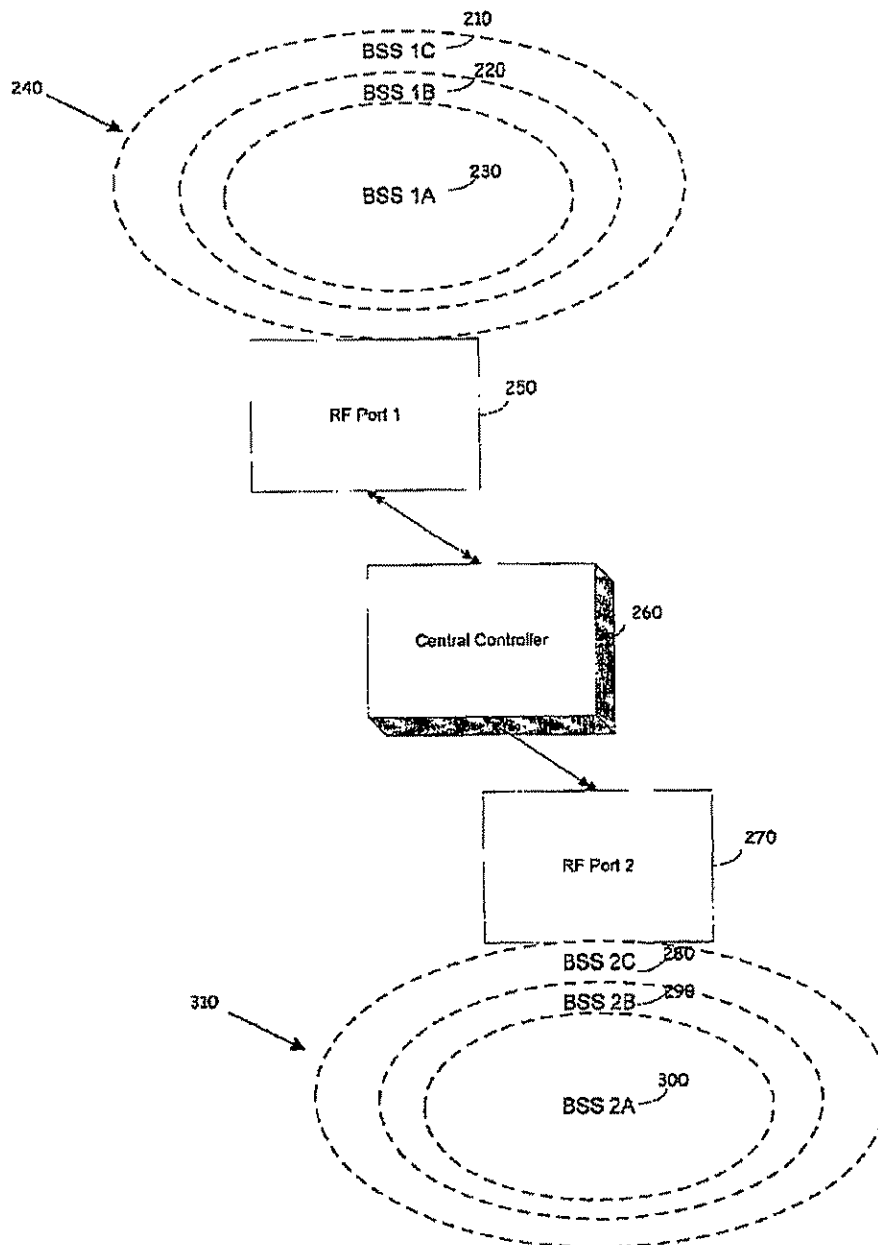
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## FIG. 8



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# MULTIPLE WIRELESS LOCAL AREA NETWORKS OCCUPYING OVERLAPPING PHYSICAL SPACES

## REFERENCE TO PRIOR APPLICATION

This application is a continuation-in-part of pending application Ser. No. 09/528,697, filed Mar. 17, 2000.

## BACKGROUND OF INVENTION

This invention relates to wireless data communications networks, and in particular to arrangements for communications between mobile data handling units and a central computer using wireless data communications.

The assignee of the present invention supplies a wireless data communications system known as the Spectrum 24 System, which follows the radio data communications protocol of IEEE Standard 802.11. In the system as implemented, mobile units are in data communication with a central computer through access points. The access points may communicate with a central computer or computers over a wired network. Each of the mobile units associates itself with one of the access points. The access points in this system are functional to perform all the implemented requirements of the standard protocol, including, association and roaming functions, packet formulation and parsing, packet fragmentation and re-assembly encryption and system access control. In order to maintain order and reduce radio communications each access point must determine which of the data communications received over the wired network from the central computer is destined for a mobile unit associated with that particular access point. This requirement adds significant computational capacity to the access point, increasing the cost thereof.

In addition, in applications that must support a high volume of data communications from multiple users, such as systems supporting a self-service shopping system, hospital systems, systems that include paging or voice data links to many users, or systems supporting communicating with electronic shelf labels, additional access points are required to support the data communications traffic, increasing the overall system cost.

The cost of an operational access point is dependent not only on the complexity thereof and the requirement for high speed processing of data packets for purposes of selecting those destined for mobile units associated with an access point, but the additional cost of the installation of electrical power to the location of the access point, and the cost of a power supply to convert AC electrical power to DC power for the circuits of the access point. Further cost may be involved in physically mounting the access point hardware and antenna.

In prior systems each access point is connected on an Ethernet wired network to the central computer. The access points are required to determine the identity of mobile units which have become associated with them and to extract from the data packets on the Ethernet network those packets addressed to a mobile unit associated with the access point. This requirement has led to significant processing burden for the access points and led to increased cost for the access points.

In the system described in my prior published International Patent Application WO 099 37047, published Jul. 22, 1999, the central computer communicates over an Ethernet wired network with an intelligent switching hub. Alternately a token ring network can be used. The switching hub

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determines the destination of each packet and routes packets to an access point if the destination of the packet is a mobile unit associated with the access point. To achieve this function, the hub is an intelligent hub which maintains a routing list of mobile units and their associated access point according to the port of the hub.

In practice, the hub need only maintain a source list for those access points connected to the hub and mobile units associated with the access points connected to the hub. Thus, if a packet is received at a hub over the Ethernet with a destination address which is not associated with that hub, the packet is ignored. The hub will route the packet to an access point only if the destination address of the packet is identified on the list. When a packet is received on a hub port associated with a communications line connected to an access point, the source address is associated with the hub port in the list. The packet is routed either to the Ethernet connection or to another port according to the destination address.

By determining destination address in the hub and maintaining the association of a mobile unit address with an access point connected to a port of the hub in a routing list of the hub, the functionality required of the access points is greatly reduced. The access point acts merely as a conduit sending RF transmissions of packets received on its communication line, and receiving transmissions from associated mobile units and providing Ethernet packets to the hub. In addition, the access point must provide mobile unit association functions and other 802.11 protocol functions, as provided in the Spectrum 24 system, and may also provide proxy polling responses for associated mobile units that are in power saving mode.

The prior system may have a large number of access points, each with a memory containing program instructions for carrying out the various required functions. This distribution of processing makes it difficult to upgrade a system or to provide changes in system configuration because any upgrade or change may require changes to the program code in each of the access points. Such distribution of processing functions also makes system management functions, such as load balancing or access control more difficult.

It is therefore an object of the present invention to provide an improved wireless data communications methods and systems having lower cost, to enable the economical provision of reliable wireless data communications with increased capacity in complex installations or at reasonable cost or simple installations.

## SUMMARY OF THE INVENTION

In accordance with the invention there is provided a system for providing wireless data communications between mobile units and a wired network. The system includes a plurality of RF ports having at least one data interface and arranged to receive formatted data signals at the data interface and transmit corresponding RF data signals and arranged to receive RF data signals and provide corresponding formatted data signal. There is also provided at least one cell controller, arranged to receive data signals from the wired network and to provide formatted data signals corresponding thereto and to receive formatted data signals and to provide data signals corresponding thereto to the wired network, the cell controller controls association of mobile units with one of the RF ports, provides formatted data signals for said mobile units to an associated RF port and receives formatted data signals from the mobile unit from the associated RF port.

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In accordance with the invention there is provided an improvement in a wireless data communications network coupled to a data processing system, having a plurality of RF ports and mobile units, wherein the mobile units associate with one of the RF data communications ports to conduct data communications with said data processing system. The mobile units are assigned to one of the RF ports by a cell controller, and the cell controller is arranged to receive first data communications from the data processing system and to relay the data communications to an assigned RF port and to receive second data communications from the RF ports and relay the second data communications to the data processing system.

In accordance with the invention there is provided a method for operating a wireless local area network having at least one RF port, a plurality of mobile units and a cell controller coupled to the RF port. The RF is operated port to relay signals received from mobile units to the cell controller and to relay signals received from the cell controller to the mobile units. The cell controller is operated to control association of the mobile units with the RF port, including sending and receiving association signals between the RF port and the cell controller, and to send messages to and from the mobile unit via the RF ports.

In accordance with the invention there is provided an improvement in a mobile unit for use in a wireless data communications system, wherein the unit has a data processor and programs for the data processor and a wireless network adapter having a programmed processor and a radio module. The programmed processor performs first communications processor functions including control of the radio module and the data processor operates under the programs to perform second communications processor functions, including association with a radio access location of the wireless data communications system.

According to the invention there is provided an improvement in a wireless data communications system for providing data communications following a standardized protocol, wherein the protocol includes association of mobile units with radio access locations. At least one RF port is provided at a radio access location, which RF port comprises a radio module and an RF port processor in data communications with a programmed computer. The RF port processor performs first functions of the standardized protocol and the programmed computer performs second functions of the standardized protocol, including the association of mobile units with said radio access location.

According to the invention there is provided an RF port for use in a wireless data communications system comprising a radio module having a data interface and a transmitter/receiver for wireless data communications; and a digital signal processor having first and second data communications ports, random access memory and read-only memory. The second data communications port is coupled to the data interface of said radio module. The read-only memory is provided with a bootloader program for controlling the digital signal processor to load program instructions to the random access memory via the first communications port. According to the invention there is provided a method for operating an RF port having a radio module, a digital processor, random access memory and read-only memory. A boot-loader program is stored in the read-only memory. The digital processor is operated to download instructions from a computer to the random access memory using the boot-loader program and the RF port is operated under the downloaded instructions to send and receive messages using the radio module.

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According to the invention there is provided a method for transmitting signals having a wireless signal format using an RF port having a wired network interface, a data processor and an RF module. Signals are provided to the wired network interface having wireless address data and message data within a data packet addressed to the RF port using a protocol for the wired network. The processor is operated to provide wireless data signals having the wireless signal format for the address data and the message data to said RF module and operating the RF module is operated to transmit the wireless data signals as an RF signal modulated with the wireless signal format.

According to the invention there is provided a method for transmitting signals having a wireless signal format using an RF port having an Ethernet interface, a data processor and an RF module. An Ethernet data packet is provided to the Ethernet interface, the Ethernet data packet encapsulating as data a data message having the wireless signal format. The data processor is operated to provide the data message to the RF module. The RF module is operated to transmit the data message as an RF signal.

According to the invention there is provided a method for receiving signals having a wireless signal format including wireless address data and message data at an RF port having a wired network interface, a data processor and an RF module. The RF module is operated to receive RF signals having the wireless signal format. The data processor is operated to receive wireless data signals from the RF module and provide data signals to the wired network interface comprising a data packet having a source address corresponding to the RF port using a protocol for the wired network, the data packet including the wireless address data and the message data.

According to the invention there is provided a method for receiving RF message signals having a wireless signal format including an address data format and message data using an RF port having an Ethernet interface, a data processor and an RF module. The RF message signals are received in the RF module and provided as data signals to the data processor. The data processor is operated to interpret address data in the data signals and, in dependence on the address data, said message data and said address data is encapsulated in an Ethernet packet, which is provided to the Ethernet interface.

In accordance with the invention there is provided a simplified wireless local area network system including a computer having a data processor and a memory, an RF port having an RF port data processor, an RF module and a data communications interface coupled to the computer. A first program is provided in the memory of the computer for operating the computer data processor to perform first wireless data communications functions, including association with mobile units. A second program is provided for operating the RF port data processor to perform second wireless data communications functions.

According to the invention there is provided a wireless access device for providing wireless access to a communication system. The device includes a modem for sending and receiving data messages on the communications system and an RF port, having a data interface coupled to the modem, a data processor and an RF module. The data is programmed to receive data messages from the modem, to format the messages for wireless data communications and to provide the formatted messages to the RF module for transmission by RF data signals to at least one remote station, and to receive RF data signals from the at least one remote station,

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and to provide data messages to the modem to be sent on the communications system.

According to the invention there is provided a method for providing wireless access to the Internet. A modem having a data communications interface connected to an RF port is connected to the Internet. The RF port is configured for wireless data communication to at least one mobile unit having a predetermined wireless communications address. A mobile unit configured with the predetermined wireless communications address is provided for conducting RF data communications with the RF port. The RF port is arranged to relay communications between the mobile unit and the modem.

The apparatus and methods of the present invention provide RF ports as radio access locations which are less expensive than known access points and provide greater system management and flexibility. Much of the software used for controlling communications to and from mobile units is performed in a controller wherein software upgrades and changes are easily implemented. According to some embodiments, wherein instructions are downloaded to RF ports, it becomes easy to upgrade RF port instructions. System control is centralized, making management easier and enabling changes to access control and encryption functions. Priority for traffic purposes can also be established to facilitate digital telephony by giving priority to voice traffic. Accordingly, a system is provided that has significant flexibility using common RF port hardware to provide a wireless LAN having from one to hundreds of radio access locations.

According to the invention, the same RF port may provide multiple ESS identifications such that each ESS identification is associated with a separate virtual wireless local area network having its own policies and security.

For a better understanding of the present invention, together with other and further embodiments thereof, reference is made to the following description, taken in conjunction with the accompanying drawings, and its scope will be pointed out in the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a wireless communications system in accordance with the present invention.

FIG. 2 is a block diagram illustrating one example of a mobile unit arranged to be used in the system of FIG. 1.

FIG. 3 is a block diagram illustrating one example of an RF port for the system of FIG. 1.

FIG. 4 is a more detailed block diagram of a preferred embodiment of an RF port in accordance with the invention.

FIG. 5 is a block diagram of an arrangement of a computer and RF port for providing a simplified wireless local area network according to the present invention.

FIG. 6 is a block diagram of an arrangement for providing wireless access to the Internet using the RF port of the present invention.

FIG. 7 is a diagram showing signal format according to one embodiment of the invention.

FIG. 8 is a diagram showing an compilation of RF ports having multiple ESS arrangements for providing overlapping, multiple wireless networks.

#### DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown an example of a wireless data communications system 10 according to the

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present invention for providing data communications between a central computer or a collection of computers on a wired network 16 and a plurality of mobile units 20. While prior systems used access points at each radio access location, where the access points are capable of managing wireless communications with mobile units, the system of FIG. 1 uses simplified RF ports 18 at each radio access location to provide radio packet communications with the mobile units 20 using a wireless communications protocol, such as IEEE Standard 802.11, whereby the radio modules in the mobile units 20 monitor polling signals from the RF ports 18, which are originated by the cell controllers 14 and associate with an RF port 18 for purposes of data communications. The system arrangement of FIG. 1 is especially effective in a large wireless local area network (LAN) system wherein it may be necessary to provide a large number of radio access locations. Typically such systems, operating at low power microwave frequencies, require radio access locations at about every 100 feet. Where the wireless LAN system must operate with mobile units, for example, portable computers or similar devices, located throughout a large facility, such as a business, hospital complex or university campus, many such radio access locations may be required, possibly several hundred. Accordingly there is an incentive to reduce the cost of the installation at each radio access location. According to the present invention the system configuration and operation are redesigned to reduce the cost of each individual radio access point. In addition, the system of the present invention provides a concentration of operational control in one or more central controllers 14, making management of the system easier and making modifications and upgrades easier to install.

According to the invention, much of the functionality of the 802.11 protocol associated with the conventional access point, is removed from the device located at the radio access location and provided in a cell controller 14, which may be located in conjunction with a switching hub 12, connected to the wired network 16, with which the wireless network 10 is associated. In particular the usual "access point" device is replaced with a simpler device 18, herein referred to as an "RF port" which contains the RF module, which may be the same RF module used in the prior art access point, and simplified digital circuits to perform only a limited portion of the 802.11 media access control (MAC) functions performed by the prior art access point. In particular the RF port 18 preferably performs only functions of the access point that require a lower level of processing resources in terms of processor capacity and software complexity (memory requirement), and which are time critical. Other functions that are more processor intensive and require more complex programming, and which are not time critical, are relegated to one or more "cell controllers" 14, which may perform these more complex functions for a plurality of RF ports 18.

In order to perform the higher level processing functions of the access point in the cell controller 14, according to the present invention, all messages directed to or from mobile units 20 associated with a particular RF port 18 are processed in a cell controller 14. A system may have one or more cell controllers, which may comprise, e.g. Pentium-type board level computers, each of which is arranged and programmed to handle data message traffic and mobile unit associations for a selected plurality of RF ports 18. A switching hub 12 may be interposed to provide message switching among the wired network connected to communications line 16, RF ports 18 and cell controllers 14. Each of the one or more cell controllers 14 acts as a virtual "access



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point" for traffic addressed to its associated RF ports 18 and to the mobile units 20 associated with those RF ports. When a message is addressed to a mobile unit 20 is received on line 16, switching hub 12 directs the message to the appropriate cell controller 14, which reformats the message and relays the message to the appropriate RF port 18, again through switching hub 12. When the message is received by an RF port 18, it is converted to a radio message and sent to the mobile unit 20 with a minimum of processing.

Likewise, when a message is received from a mobile unit 20 by an RF port 18, it is converted to a digital message packet and relayed to the cell controller 14 associated with the RF port 18 through the switching hub 12. The cell controller 14 parses the message for further relay in the system.

An important feature of a preferred embodiment of the invention is the fact that mobile unit association with the RF ports 18 is a function handled by the cell controller 14. Accordingly, when a mobile unit 20 first becomes active, it sends an association request signal in response to a beacon signal sent by an RF port 18 (in response to direction by the cell controller). The association request signal is relayed by the RF port 18 to the cell controller 14, which performs the processing required for association, including consideration of RF port loading. Cell controller 14 generates appropriate response signals to be sent by the RF port 18 to the mobile unit 20. The cell controller 14 is in an appropriate position to evaluate the loading of the RF ports 18 under its control, and may therefore easily perform load leveling functions, for example, by providing a message to RF port 18 accepting or declining an association request. In addition, the cell controller 14 may receive load messages from other cell controllers 14 in the system 10 and thereby coordinate overall load management. As a mobile unit 20 moves from a location serviced by one RF port 18 to a location serviced by a different RF port 18, the cell controller 14 receives information from the mobile unit 20 indicative of its reception of beacon signals from the various RF ports in the system and performs the necessary functions to support roaming of mobile unit 20.

While in the system 10 of FIG. 1 the cell controllers 14 are shown as separate computers connected to switching hub 12, the term "cell controller" is intended to refer to the logical functions performed by these computers rather than the computers themselves. As will become apparent, the cell controller may be implemented in a variety of ways other than as shown in the exemplary system 10 of FIG. 1.

Implementation of a simplified RF port is achieved by performing "higher level" functions of the 802.11 protocol Media Access Control (MAC) in the cell controller and performing "lower level" functions in a simplified RF port.

The lower level functions are those that are hardware intensive and often time critical. The higher level functions are those that are software intensive and not time critical. One possible division of the exemplary 802.11 MAC functions is as follows:

Lower Level Functions (preferably to be performed at RF port)

- Cyclic Redundancy Check (CRC)
- Network Activity Vector (NAV)
- Ready to Send/Clear to Send (RTS/CTS)
- Header generation/parsing
- Collision Avoidance
- Frequency Hopping

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- Ack parsing/generating
- Retransmission timeout
- Higher Level Functions (preferably to be performed at Cell Controller)

- Association processing
- Roaming
- Retransmission
- Rate Control

- Host Interface

The following optional (higher or lower) level MAC functions can be placed in either the higher or lower level categories.

- Wired Equivalent Privacy encryption/decryption (WEP)
- Fragmentation/Reassembly
- Data Movement
- Power Save Polling Support (PSP)

According to a preferred arrangement of the system of the invention, the lower level MAC functions are provided at the RF port, the higher level MAC functions are provided in the cell controller and the optional level functions can be provided at either the cell controller or the RF port.

A major advantage of the invention is a cost savings in hardware, processor capacity and storage capacity for the RF port. Since a system with, for example, one hundred or more radio access locations may be implemented with one or two cell controllers, the processor hardware and memory required for the higher level MAC functions need be provided only at the cell controllers. In fact, the capabilities of the overall system, for WEP encryption and other special functions, can be increased at modest cost by using a high performance board level personal computer or even a host computer as a cell controller.

By eliminating the higher level MAC functions from the radio access locations, the cost of the devices installed at those locations can be significantly reduced because of lower processor capacity and storage.

In connection with association and roaming functions the RF ports 18 provide beacon signals in response to commands generated by the cell controller 14. When an association sequence is initiated by a mobile unit, the RF port 18 relays the association messages between the mobile unit 20 and the cell controller 14 during the association process, which is handled by the cell controller 14.

In connection with message traffic to a mobile unit 20 from a network processor, message packets are routed by switching hub 12 to the cell controller 14 responsible for the mobile unit 20 addressed. The message is buffered and formatted by the cell controller 14 and in a preferred arrangement encapsulated by the cell controller 14 as a mobile unit packet within a wired network packet addressed to the responsible RF port 18. This packet is routed to the RF port 18. The RF port 18 extracts the mobile unit packet from the message and sends the packet to mobile unit 20 as a radio signal. The RF port 14 may also provide a CRC calculation and generate CRC data to be added to the message. The mobile unit 20 responds with an acknowledgment signal to the RF port 18, which generates and sends an acknowledgment status message to cell controller 14.

In connection with messages for systems connected to the wired network 16, the mobile unit 20 sends a packet to the RF port 18 by radio signal. The RF port 18 filters received radio message packets according to the BSS (Basic Service Set) identifier in the packet and, if the packet has a BSS identifier associated with the RF port 18, performs the CRC check as the packet is received. The RF port 14 then

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generates and sends an acknowledgment signal to the mobile unit 20 and sends the received packet to cell controller 14. Cell controller 14 buffers, parses and, if necessary, decrypts the packet and routes the packet to the host on network 16 through hub 12.

The arrangement of RF port 18 may be identical to current access points used in the Spectrum 24 system with some of the access point software non-functional. Preferably the RF ports are simplified to reduce cost and power consumption. To reduce installation expenses the RF ports are powered via an Ethernet cable, which also connects RF ports 18 to switching hub 12 or to cell controller 14. The RF ports can be arranged in a small package (e.g. portable radio size) with integrated diversity antennas and arranged for easy mounting, such as by adhesive tape or Velcro. Connection to the switching hub 12 is by Ethernet cable which is also provided with D.C. power, such as by use of a choke circuit, such as Pulse Model PO421 as described in my referenced International Application. The choke circuit may be built into an Ethernet connector and is available in this configuration.

The RF port 18 does not have to perform Ethernet address filtering and does not have to perform 802.11 association and roaming functions and can therefore have a lower level of processor capacity, software support, memory and power consumption. In one embodiment shown in FIG. 3 the RF port 18 includes only a digital signal processor (DSP) 38 which includes internal RAM and ROM. The DSP 38, which may be one of the Texas Instruments TMS 320 family of DSP processor, such as the 5000 series, specifically the TMS 320 UC 5402 or the TMS 320 VC 5402. This DSP provides an interface between the Ethernet cable 46 and the RF module 42 in RF port 18, as shown in FIG. 3. The RF module 42 is provided in housing 36 with DSP 38, DC/DC power supply 40 and carrying one or more antennas 44. RF module 42 includes a 3860 or 3861 baseband processor, such as HFA 3860B, to interface with the digital portion of the RF port 18, specifically DSP 38. In one arrangement the ROM memory of the DSP 38 can be provided with "bootloader" firmware that downloads the necessary DSP software instructions from the cell controller 14 upon startup of the RF port 18, and loads the instruction into the RAM of the DSP 38.

The processors that are currently preferred as a possible lower level MAC engine are the TMS320UC5402 and the TMS320VC5402. These parts are functionally identical except for differences in power consumption (the VC5402 is currently in production and while the UC5402 is still being sampled). The basic configuration of the UC5402/VC5402 is:

- 100 MIPS execution rate
- 8 KB on chip ROM (organized as 4Kx16 bits)
- 32 KB on chip RAM (organized as 16Kx16 bits)
- Two 16 bit timers with 1  $\mu$ s or better resolution
- Two High speed, full duplex serial ports (up to 50 Mbits/sec each) with smart DMA channel support
- One High speed 8 bit wide host/parallel port (160 Mbit/sec)
- Six DMA channels for general purpose use
- 16 bit external memory/IO Bus with internal wait state generation
- 16 interrupts with 3 instruction (30 ns) worst case latency
- 0.54 mW/MHz power consumption (30 mA@1.8 v at 100 MHz)
- Low Power Modes (6 mA, 2 mA, 2  $\mu$ A depending on setting)
- Internal PLL that generates the system clock with an external crystal

This section will describe the use of a 5402 DSP 38 as a MAC engine for 11 Mbit/sec 802.11 DS systems. It could

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clearly be used in FH systems as well. We will focus on the how the 5402 interfaces to the Intersil 3860/1 baseband processor in RF module 42 and how it implements the lower level MAC functions.

The first issue is how the 5402 DSP 38 interfaces to the 3861 (much of what is said applies to the 3860 as well) and the rest of the RF module 42. As shown in FIG. 4, the 3861 processor 53 in RF module 52 of RF port 50 has 2 major interfaces, both serial. The first interface, labeled DATA, is used to transfer data between the MAC engine comprising DSP 64 and the 3861. It has four lines: Tx/D, Tx/C, Rx/D, and Rx/C and operates at up to 11 Mbits/sec. The exact rate depends on the transfer rate of the packet. The clock signals of both interfaces are generated by the 3861 and so transfers are controlled by the 3861. Both can be halted at any time by the 3861 as well as change rate. The second serial interface, labeled CONTROL is used to load commands into the 3861 and read status information from the 3861. This interface is a 4 wire bi-directional interface using one data line, one clock line, one "direction control" line, and a chip select line. This serial interface also can operate at up to 11 Mbits/sec. In addition to the serial interfaces, there are additional control and status lines such as Reset, TX\_PE, RX\_PE, TX\_RDY, etc.

The 5402 DSP 38 has two sets of full duplex serial interfaces that are capable of operation up to 50 Mbits/sec (given a 100 MHz clock). They can be clocked using internal or external sources. In this design one of the sets of serial interfaces, labeled SER1, is used to connect to the high speed data lines of the 3861 interface 53. The 5402 DSP 38 interfaces have the same basic lines (Rx/D, Rx/C, Tx/D, Tx/C) as does the 3861 and so they connect with minimal trouble. Although the 5402 uses 1.8 v for its core, its I/O lines are 3.3 v tolerant and so can interface to the 3861 without converters. In addition, they are fully static and so can deal the start/stop operation of the clock lines from the 3861.

Data transfer will be done under DMA control within the 5402 using what TI calls "Auto Buffering Mode." This provides essentially dedicated DMA channels for each serial port interface (two DMA channels per serial port interface). These channels access an independently operating bank of SRAM and so transfers have no impact on CPU performance. The CPU can start transfers in either direction and be notified via interrupt on their completion.

Interfacing to the control serial port on the 3861 interface 53 can be done in three different ways. The first, illustrated in FIG. 4, utilizes the second serial port, labeled SER 2 on the 5402 DSP 64 with a small amount of combinatorial logic/buffering to convert between the single data line of the 3861 and the dual data lines of the 5402. Another approach is to use an external shift register that would perform serial/parallel conversion. This register would sit on the I/O bus of the 5402 and would be loaded/read by the 5402 and data shifted between it and the 3861. The third approach is to use an external buffer/latch on the 5402 I/O bus and "bit bang" the clock/data lines to the 3861. The second or third approaches free up the second serial channel for more other use such as providing high speed serial interfaces such as Ethernet or USB and in some applications would be preferred over the first. All require a small amount of external combinatorial logic and so the cost of all solutions is about the same.

The same logic would apply to interfacing to the synthesizer. It is accessed even less often than the control port of the 3861 and so a "bit banging" approach would work fine.

Finally, interfacing to the various control and status lines presented by the 3861 can be done via simple bi-directional

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register/latch connected to the I/O bus of the 5402. The 5402 can read/write this register as it needs to control and monitor the 3861. It would be possible to combine all control/monitor functions (including the serial control interface) into a single 16 bit buffered register latch. Parallel control/status lines would be connected to particular lines of this latch. Serial control interfaces would also be connected and "bit banged" as necessary to move data between the 5402 and 3861.

The arrangement shown in FIG. 4 uses a Crystal CS 8900 A Ethernet controller 63 coupled to the parallel port of DSP 64 to interface to the Ethernet port 58. An Ethernet connector/choke 58 receives cable 60 and provides DC power from cable 60 to DC/DC power supply 62. The FIG. 4 RF port 50 includes spaced diversity antennas 54, 56 to improve reception in multipath conditions.

A promise of this design is that the TI DSP is capable of implementing all lower level MAC functions without external hardware assistance. This, of course, is the most demanding model but we will find that the 5402 is up to the task. The most computational demanding tasks are the CRC-32 and WEP processing. The CRC-32 calculation is performed over the entire packet and must be completed in time to generate an ACK should the CRC turn out to be correct (or to attach the calculation result to an outgoing packet on transmission). This means that the CRC calculation must be performed in near real-time during packet transfer between the 3861 and 5402. TI has shown in an application note that a CRC-32 calculation can be made by a 5600 series DSP in 13 instructions. At 100 MIPS this is about 130 ns. At 11 Mbit/sec, a byte takes about 770 ns to transfer and so we have plenty of time to do the CRC. When receiving a packet, the serial port would be transferring the data from the 3861 to SRAM within the 5402. At the same time the CPU within the 5402 would be reading each received byte from SRAM and calculating the CRC. It would of course have to make sure that it did not overrun the receive buffer, but that would be a relatively simple task. Much the same process would happen during transmission. In either case, the CPU has lots of time to do the CRC.

The WEP processing if performed in the RF port 50, is a harder function to perform than CRC-32 since it includes both an RC4 encryption function and a second CRC-32. At the same time it does not need to be completed prior to ACK generation/reception nor is performed on every packet (just data packets). The RC4 encryption function consists of two parts: building the encryption table (a 256 byte table) using the selected key and doing the encryption/decryption process. Based on sample code, it is estimated that building the table would require about 1200 instructions (12 ms at 100 MIPS) and the encryption/decryption process would require about 12 instructions/byte. There is no difference in this cost for 40 or 128 bit keys. The WEP CRC-32 would require another 13 instructions per byte.

The per byte computational burden for WEP would thus be about 25 instructions or about 250 ns at 100 MIPS. When added to the packet CRC-32, the total load would be around 38 instructions/byte. As we pointed out, at 11 Mbit/sec we have about 77 instructions/byte available, so we are spending about 50% of the CPU on CRC/WEP tasks. The biggest issue is the 1200 clocks (12 us) required to build the encryption table during receive (For transmission, the calculation can be done prior to starting packet transfer). Pausing to create the table would put the CPU about 18 bytes (12 us at 770 ns/byte) behind in the CRC/WEP/CRC calculation process. It would require about 40 data bytes to catch up (1200 clocks/30 extra clocks per byte) in both

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packet CRC and WEP/CRC functions. Since the minimum TCP/IP header is at least 40 bytes (plus any user data), we should have enough time. In any case if we are a little late in WEP/CRC calculation, no harm is done. An alternative approach would be to catch up first for the packet CRC calculation and then catch up with WEP/CRC.

After CRC and WEP/CRC processing, the next most critical activity is header parsing on receive and generation on transmit. This is because of the need to identify packets for the station and generate appropriate responses. On receive, the processor must parse two or three 48 bit addresses and at least a 16 bit header command field. After the packet completes, an ACK may need to be generated.

The 5402 can easily handle these functions. Since these functions are performed prior to WEP processing, the CPU has 64 instructions/byte (77-13) to perform these functions. Since many of them can be performed on a 16 bit or even 32 bit basis (the 5402 supports both 16 and 32 operations), there may be up to 128 or 256 instructions per data item (i.e. 256 instructions to perform a 32 bit address check). These functions are performed at 2 Mbit using a 1 MIPS 188 CPU. We have a 100 MIPS CPU to do the same tasks at 11 Mbit/sec.

ACK generation is likewise relatively simple. An ACK frame is only 14 bytes long, including the 4 CRC-32. Given there is a long (80 us) preamble, we have 8000 instructions to prepare the ACK. The same applies to RTS/CTS exchanges.

There are two 16 bit timers available on the 5402. In this model, one would be used for TSP timing and the other for all other functions. There are really only a few other timer functions: NAV, Retransmission, collision avoidance slot countdown, etc. Retransmission and collision avoidance activities go on only when waiting for an ACK or to start a retransmission after detection of an idle network. In such cases there is no data transfer going on and so there is lots of CPU cycles available.

Support for MU PSP function can be done in a variety of ways, depending on how much, if any, external hardware is provided. The 5402 provides a variety of means of conserving power. The first is simply to slow down the CPU clock via the software controlled PLL within the unit. The 5402 generates internal clocks via a PLL that is driven by either an external crystal or clock. The PLL multiplies the base frequency of the crystal/external clock by a factor determined by software. Hence one means of controlling power consumption is simply to slow down the CPU clock. Since the CPU portion of the processor consumes most of the power, slowing it down has the biggest affect on power consumption.

The second approach is use one of the IDLE modes of the processor. IDLE1 stops the CPU clock entirely but leaves everything else running. Power consumption in this mode is on the order of 6 mA at 100 MHz. The CPU can be restarted by any interrupt (internal or external). In IDLE2 the system clock is stopped and this reduces consumption to 2 mA. In IDLE3, all system functions are stopped and consumption is reduced to around 2 ua. In all cases all state is retained. In IDLE2 and IDLE3, an external interrupt is required to restart the CPU. In such cases an external, low power timer would be required.

Thus with no external hardware, power consumption could be reduced to at least 6 mA and perhaps less. With a simple external timer, one could get down to microamps.

The bottom line is that the vast CPU power of the 5402 allows all lower level MAC functions to be performed in software. Furthermore it has sufficient power and memory to



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handle additional "higher level" functions such as packet retransmission, fragmentation, and reassembly that can also be done in a cell controller.

The system 10 of the present invention is compatible with IEEE Standard 802.11 and accordingly will operate with any mobile units 20, including existing units, which are compatible with the same standard. However, the improvements applied to the RF ports 18, reducing the complexity and cost of these units can also be applied to the mobile units 20, which have sufficient main processor capacity to handle the mobile unit functions corresponding to the higher order MAC functions.

Referring to FIG. 2 there is shown a block diagram for a mobile unit 20 having a mobile unit computer 22 and a WLAN adapter 24 connected thereto to provide wireless communications to the system 10 of FIG. 1. In the mobile unit 20 of FIG. 2, the lower level MAC functions are performed in WLAN adapter 24, which also includes RF module 28 and antenna 29. The configuration of WLAN adapter 24 may be similar to existing adapters, but preferably adapter 24 is simplified to perform only the lower level MAC functions of the IEEE 802.11 protocol and allow special software 34 in host computer 22 to perform the higher level MAC functions, such as association and roaming. In a preferred arrangement the MAC functions of adapter 24 are performed in a digital signal processor 26, as described below, which may be the same type DSP described with respect to RF port 50.

This section addresses how the 5402 DSP could be used as a MAC engine in Mobile Unit configurations. There are two considerations in building MU WLAN solutions. The first is the location of those MAC functions, while the second is the physical interface to the host.

The location of the upper level MAC functions may vary considerably. Some possibilities are:

All functions on MAC engine DSP processor 26

All functions on host processor 22

Roaming/association on host processor 22, rest on MAC engine 26

Roaming/association/retransmission on host 22, rest on MAC engine 26. The choice of the location of the higher level MAC functions has a major impact on the cost of MU WLAN adapter. If one is willing to place at least some of the higher level functions on a host processor 22, then one could get by with just the 5402 on the WLAN adapter. Possible functions to place on the host would be roaming and association control. Higher level functions such as retransmission and fragmentation/reassembly could be left on the 5402. This split would permit significant savings, since another processor/memory subsystem would not be needed on the WLAN adapter. There are two reasons for not placing all of the MAC functions on the 5402. The first is memory space on the 5402 is only 32 KB of SRAM for both code and data. In some MAC implementations such as frequency hop, the code space alone exceeds 32 KB. The second reason is that the software on the 5402 is oriented toward meeting hard, real-time tasks such as CRC and WEP processing. Trying to add software intensive tasks would only complicate the process.

If another processor was required, such as an ARM or perhaps a second 5000 Series processor, the upper level functions could be added to it.

Alternatively one could place all the MAC functions on a faster and/or bigger version of the 5402 processor. Such a processor would likely have a higher clock rate (current members of the 5000 Series can be clocked as high as 160 MIPS) and more memory (say 64 KB instead of 32 KB).

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Both the second processor as well as a faster/bigger 5402 would consume additional power as well as adding cost.

This section will describe one approach of how a MU WLAN adapter can be arranged for various hardware host interfaces using the 5402. It assumes that enough of the upper level MAC functions have been offloaded to a host processor so that only the 5402 is required on the WLAN adapter. A second processor could be added to any of the solutions outlined below.

In all of the following solutions, it is assumed that the runtime code for the 5402 is loaded from an external source (such as computer 22) via the host interface 32. This eliminates the need for flash memory on the adapter card, saving several dollars in the process. It should be pointed out that the 5402 comes with 8 KB of mask programmable ROM and a bootloader program (required for the USB and Ethernet host interfaces) would be placed in it. The bootloader would be smart enough to download the runtime code instructions over whatever serial interface was available.

The simplest interface of all would be for a host to use the Host Port on the 5402. This port operates as a dual port interface into the memory within the 5402. It would not be a standard interface but would be quite suitable for dedicated systems. Using it, computer 22 can read/write memory on a random or sequential basis. It is an 8 bit interface and can operate as fast as 160 Mbit/sec. When operated in random access mode, the computer 22 generates a 16 bit address using two writes to the port and then performs either a read or write operation. Such a mode allows a host to set up command blocks and the like within the memory of the 5402. Sequential mode allows a host to transfer data in and out of the 5402 memory very quickly (160 Mbit/sec). This would be used for transferring data.

If this approach was used, the only digital component on the WLAN adapter would be the 5402.

In the system of FIG. 1, the cell controller 14 is a board level personal computer coupled to the switching hub 12 preferably by 10 M bit and 100 Mb Ethernet ports. For smaller systems a 350 MHz Pentium computer with 16 MB RAM may be used. For larger systems having many RF ports a 500 MHz Pentium with 64MB RAM is appropriate. Communications to and from the wired network are preferably carried out at 100 MHz. Communications to and from RF ports may be carried out at 10 MHz. A second cell controller may be supplied for larger systems and/or to provide backup in the event one cell controller fails. Reliability can be enhanced by providing dual fans and dual power supplies. A flash disk memory may be used for reliability. Alternately, the cell controller 14 may be built into the switching hub 12 or into a host processor.

The operating system for the cell controller 14 may be a real time operating system, such as VRTX or QNX, which provides multitasking, a full network stack and utilities. Web based management utilities, which are client side java based, are provided for maintaining the configuration of the cell controller 14, the RF ports 18 and status of the mobile units 20.

The cell controller 14 includes applications to provide mobile unit association management, roaming and packet buffer management. These applications are similar to those performed by current access points in the Spectrum 24 system. The cell controller 14 may also provide QoS support, user authorization and configuration management. Placing these functions on a personal computer cell controller facilitates system management and program updates using available programming tools. Further, modifications to authorization or management functions need only be



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installed into the cell controller 14, and no modification to the software of the RF ports 18 is required.

The cell controllers 14 handle routing of all messages to or from the mobile unit. The cell controller buffers message packets received from the wired network and determines the appropriate RF port 18 with which the addressed mobile unit 20 is associated and sends the packet to the RF port 18. The cell controller 14 can additionally perform WEP encryption/decryption and the CAC associated therewith.

The cell controller 14 may also the additional function of maintaining and downloading firmware to the RF ports 18. Upon power up the RF ports 18 use a bootloader routine stored in ROM to send a download request to cell controller 14. The cell controller then downloads firmware to the RF port 18, including configuration information such as channel assignment, BSS and BSS identification. The cell controller 14 and RF ports 18 additionally share a common TSP clock.

The mobile unit computer 22 of mobile unit 20 is provided with similar software to perform the higher-level MAC functions as outlined above. Advantageously, the software 34 can be programmed using the same operating system as provided for the computer, and thereby provide a user interface, such as Windows, which is familiar to the user. The mobile unit software 34 provides the MAC functions of header building, roaming and association. The mobile unit computer 22 may also download firmware to the processor in the WLAN adapter 24.

As evident from the foregoing description, the hardware for RF port 18 and WLAN adapter 24 of mobile unit 20 can be substantially similar, with the possible exception of the interface to an Ethernet network or to a mobile unit host. Further, the logical cell controller function and the higher order MAC functions performed by the mobile unit host processor can be performed on any computer system.

Using the RF port 18 of the present invention coupled to a computer system, it is possible to provide either a mobile unit or a wireless network according to the software provided. Since the software for RF port 18 may be downloaded from a host system a simple combination of a computer and one or more RF ports can function as either a WLAN mobile unit as a WLAN host or both, by providing function selectable firmware to the processor in the RF port.

In the arrangement shown in FIG. 5, a personal computer 70 is provided with software 72 and connected to one or more RF ports 50A, 50B to provide a complete host system for wireless data communications. This arrangement could be used, for example, in a small business wherein office equipment is connected to server 70 by a wired network for conventional LAN operation and one or more RF ports 50 are also connected to server 70 on the LAN system to provide data communications between the server 70 and mobile units. The server can perform the higher order MAC functions and download firmware instructions to the RF ports. Alternatively, the firmware instructions can be installed on PROM memory in the RF ports.

FIG. 6 shows an arrangement for providing wireless access to the Internet using the RF port 50 of the present invention. Internet access over communications line 80 to modem 82 may be provided by cable, DSL or fiber optical transmission. RF port 50 may be provided with MAC firmware on PROM or may be configured with a bootloader program to download firmware from an ISP server. When installed in a home or office, mobile units 20 can associate with RF port 50 to initiate Internet access. The ISP server may perform the higher level MAC function or they may be provided in RF port 50.

The mobile units 20 may be the personal computers 22 in a home or office with a WLAN adapter 24 as shown in FIG. 2.

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FIG. 7 illustrates an example of communications formats that might be used in the various system embodiments of the present invention. The FIG. 7 example assumes that the configuration includes a host 90 connected to a dedicated cell controller 14, which is likewise connected to RF port 18. It should be clearly understood that the logical cell controller functions may be performed in host 90, particularly in a simple system.

In the FIG. 7 example host 90 sends message "A" having 100 data bytes via an Ethernet packet 100 to cell controller 14. Packet 100 has a destination address of the Mobile unit (M1), a source address of the host (H) and includes data (A). Cell controller 14 formats the data in 802.11 format with the destination corresponding to mobile unit (MU1) 20. The cell encapsulates this 802.11 packet with data A into an Ethernet packet 104 addressed to RF port 1 (RF1) from the cell controller (CC).

RF port 18 receives the Ethernet packet 104 from cell controller 14 and generates and sends an RF packet 112 in 802.11 format to mobile unit 20, including data A. It should be understood that 802.11 header generation can be provided at either the cell controller 14 or the RF port 18, but packet 104 must include mobile unit identification data either as an 802.11 header or otherwise to enable RF port 18 to generate the header. RF port 18 additionally performs the CRC computation and adds the result to the 802.11 packet 112.

A second message "B" having 1500 bytes of data is also shown as originating as Ethernet packet 102 from host 90 to cell controller 14. Cell controller fragments data message B into three fragments B1, B2 and B3 to accommodate the 500 byte data limit of 802.11 packets. These three fragments are sent as Ethernet packets 106, 108, 110 to RF port 18, which transmits RF signal packets 114, 116, 118 to mobile unit 20.

Reverse communication is similar. Message C has 100 bytes and is sent by mobile unit 20 to RF port 18 as 802.11 RF signal packet 200. RF port 18 encapsulates this message into Ethernet packet 208 and sends it to cell controller 14, which extracts the destination information and data to provide Ethernet message 216 to the host 90. A larger message D is sent as message fragments 202, 204, 206 to RF ports 18, relayed as Ethernet packets 210, 212, 214 to cell controller 14 and sent as a reassembled Ethernet packet 218 to host 90.

Referring now to FIG. 8, shown is an application of the central controller/RF port model that may be used to set multiple overlapping ESS LANs for use in the same or overlapping physical space. Shown in FIG. 8 is a central controller 260 which is associated with two RF ports, RF port 1 250 and RF port 2 270. The central controller 260 may be associated with more than two RF ports, but two are shown for illustration purposes. Each RF port 250, 270 provides coverage for a wireless LAN in the physical areas 240, 310.

FIG. 8 further illustrates the concept of providing multiple ESS identifications through the same RF port and cell controller such that each ESS identification is associated with a separate virtual wireless local area network having its own policies and security. Thus, RF port 1 250 may be configured so as to support separate BSS networks 1A 230, 1B 220 and 1C 210, all of which occupy the same physical space 240. The RF port may support more than three BSS networks, but three are shown for illustration purposes. Similarly, RF port 2 270 may be configured so as to support BSS networks 2A 300, 2B 290 and 2C 280 all of which occupy the same physical space 310. Using the configuration as shown in FIG. 8, multiple ESS LANs may be coordinated by the central controller 260 in the physical space 240 and 310. ESS A consists of BSS 1A 230 and BSS

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2A 300. ESS B consists of BSS 1B 220 and 2B 290. ESS C consists of BSS 1C 210 and 2C 280.

As discussed in further detail above the RF ports 250, 270 preferably performs only functions of the access point that require a lower level of processing resources in terms of processor capacity and software complexity (memory requirement), and which are time critical. Other functions that are more processor intensive and require more complex programming, and which are not time critical, are relegated to one or more cell controllers 260, which may perform these more complex functions for a plurality of RF ports 250, 270. In the case illustrated in FIG. 8, the central controller handles the necessary processing of multiple ESS LANs A, B, C in the same physical space 240 and 310.

One application of multiple ESS LANs may be found on a public place, such as an airport where, for example, three levels of wireless networks may operate. A first public network level with generally open access to a wireless local area network that might provide, for example, public wireless telephone or internet access. A second network level would involve airport operations, such as luggage handling, aircraft servicing, etc. A third network level may be reserved for emergencies and security. Devices using the network can be restricted by the cell controller as to which virtual network they can access using the same RF port of the wireless network system. The cell controller would thereby control communications between mobile units accessing an RF port and the three or more virtual networks such that, for example, a member of the public using a publicly available device could only access the public functions of the system and therefore only have access to the lowest level of virtual wireless network. Other personnel, such as airport employees, may have access to the public level and also have access to the airport operational network. The security-based network would be available for select airport personnel such as management and security officers.

The cell controller performs the function of determining which ESS network a mobile unit communicating with an RF port associated with the cell controller is operating on, and thereby controls the direction of communication from the cell controller to the network. The cell controller can verify the multiple levels of security provided in connection with the access by the mobile unit devices, and in addition can prioritize communications so that higher priority communications such as security communications are given greater access to the system during higher traffic conditions. For example, in the three-tier embodiment discussed above, the security network could have a feature to disallow all other network access in an emergency situation.

A similar multi-virtual LAN network may be also useful in a health care facility wherein different networks are used for security, medical care, personal and public information.

While there has been described what is believed to be claimed in the above-identified application those skilled in the art will recognize that other and further modifications may be made without departing from the scope of the invention and it is intended to claim all such changes and modifications as fall within the true scope of the invention.

I claim:

1. A method for operating multiple overlapping wireless local area subnetworks, the method comprising:

providing a common cell controller coupled to a plurality of RF ports, wherein the common cell controller in conjunction with each RF port provides wireless medium access to all of the wireless local area subnetworks for mobile units in a designated area associated with the RF port, wherein each RF port is configured to

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perform low level medium access control (MAC) functions and the cell controller is configured to perform high level MAC functions for the coupled plurality of RF ports;

using the cell controller to provide multiple service set identifications through each RF port, wherein each service set identification is associated with a corresponding wireless subnetwork,

wherein said RF ports are operated to perform low level MAC functions and to relay signals received from mobile units to said cell controller and to relay signals received from said cell controller to said mobile units, and wherein said cell controller is operated to control association of said mobile units with said RF port, including sending and receiving association signals between said RF port and said cell controller, said association of said mobile units utilizing at least two wireless local area subnetworks occupying common physical space.

2. A method for operating a wireless local area network as specified in claim 1, wherein signals are sent, between said RF port and said cell controller using a first data protocol, and wherein signals are sent between said RF ports and said mobile units using a second data protocol, and wherein said signals between said RF port and said cell controllers comprise data packets using said first data protocol encapsulating data packets using said second data protocol.

3. A method for operating a wireless local area network as specified in claim 2 wherein said first protocol is an Ethernet protocol.

4. A method for operating a wireless local area network as specified in claim 3 wherein said second protocol is an IEEE Standard 802.11 protocol.

5. A method for operating a wireless local area network as specified in claim 4 wherein said at least two wireless local area subnetworks comprise a subnetwork for public use and a subnetwork for secure use.

6. A method for operating a wireless local area network as specified in claim 5, wherein upon activation of said subnetwork for secure use, suspending service on said subnetwork for public use.

7. The method of claim 1 wherein the RF port includes a radio module, a digital processor, random access memory and read-only memory, the method further comprising:

storing a bootloader program in said read-only memory, operating said digital processor to download instructions from a computer to said random access memory using said bootloader program, and

operating said RF port under said downloaded instructions to send and receive messages over at least two wireless local area subnetworks occupying common physical space using said radio module.

8. A method as specified in claim 7, wherein said step of operating said RF port comprises receiving messages from said computer including protocol message portions for RF message transmission, and transmitting said message including said protocol message portions as an RF signal.

9. A method as specified in claim 8, wherein said step of operating said RF port comprises receiving RF messages having an RF protocol and sending said RF messages to said computer as data signals encapsulated in a further message protocol.

10. A method as specified in claim 9 further comprising interpreting said RF protocol using said downloaded instructions and sending said RF messages to said computer only if said RF messages include an identification of said RF port.

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11. A method as specified in claim 7 wherein said downloaded instructions configure said computer and said RF port to operate as an access point for communication with mobile units.

12. A method as specified in claim 7 wherein said computer is operated to control association of said mobile units with said computer and RF port.

13. A method as specified in claim 7 wherein said downloaded instructions configure said computer and said RF port to operate as a mobile unit for communications with access points.

14. A method as specified in claim 7 wherein said downloaded instructions configure said computer and said RF port to operate as either an access point or a mobile unit under control instructions from said computer.

15. A method for transmitting signals having a wireless signal format using an RF port, the RF port having an Ethernet interface whereby the RF port is coupled to a wired network, and having a data processor and an RF module, wherein the RF port is configured to perform low level MAC functions, and wherein the wired network comprises at least one of a physical entity and a logical entity to perform high level MAC functions, the method comprising:

providing an Ethernet data packet formatted according to high level MAC functions over the wired network to said Ethernet interface, said Ethernet data packet encapsulating as data a data message having said wireless signal format according to high level MAC functions on said wired network;

operating said data processor to provide said data message to said RF module;

operating said RF module to transmit said data message as an RF signal to a mobile unit; and

operating said RF module to transmit said data message as an RF signal over at least two wireless local area subnetworks occupying common physical space.

16. A method as specified in claim 15 further comprising operating said data processor to perform a cyclic redundancy computation on said data message and adding the result thereof to said data message.

17. A method as specified in claim 15 further comprising operating said data processor to control said radio module.

18. A method for receiving signals having a wireless signal format including wireless address data and message data at an RF port, the RF port having a wired network interface whereby the RF port is coupled to a wired network, and having a data processor and an RF module, wherein the RF port is configured to perform low level MAC functions and the wired network is configured to perform high level MAC functions, the method comprising:

operating said RF module to receive RF signals from at least two wireless local area subnetworks occupying common physical space having said wireless signal format;

operating said data processor to receive wireless data signals from said RF module and provide data signals to said wired network interface comprising a data packet having a source address corresponding to said RF port formatted according to high level MAC functions on said wired network, said data packet including said wireless address data and said message data.

19. A method for receiving RF message signals having a wireless signal format including an address data format and message data using an RF port, the RF port having an Ethernet interface whereby the RF port is coupled to a wired network, and having a data processor and an RF module,

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wherein the RF port is configured to perform low level MAC functions and the wired network is configured to perform high level MAC functions, the method comprising:

receiving said RF message signals in said RF module from at least two wireless local area subnetworks occupying common physical space;

providing said signals as data signals to said data processor;

operating said data processor to interpret address data in said data signals; and,

in dependence on said address data, encapsulating said message data and address data in an Ethernet packet and providing said Ethernet packet to said Ethernet interface for transmission on said wired network according to high level MAC functions.

20. A method as specified in claim 19 wherein said data processor is operated to encapsulate said address data in said Ethernet packet.

21. A method as specified in claim 19 wherein said data processor is further operated to perform a cyclic redundancy computation on said message data and to compare the result thereof with corresponding data received in said data signals.

22. A method as specified in claim 19, further comprising operating said data processor to control said radio module.

23. A simplified wireless local area network system comprising:

a computer having a data processor and a memory;

a plurality of RF ports, each RF port having an RF port data processor, an RF module and a data communications interface coupled to said computer;

a first program in said memory of said computer for operating said computer data processor to perform high level MAC functions for said plurality of RF ports, said functions including association with mobile units via at least two wireless local area subnetworks occupying common physical space; and

a second program for operating said RF port data processor to perform low level MAC functions.

24. A system as specified in claim 23 wherein said second program operates said RF port data processor to perform second wireless data communications functions, including control of said RF module.

25. A system as specified in claim 23 wherein said second program operates said RF port data processor to perform second wireless data communications functions, including cyclic redundancy check functions.

26. A system as specified in claim 23 wherein said second program is stored in said computer memory and wherein said RF port data processor is arranged to download said second program.

27. A wireless access device for providing wireless access to a communication system, comprising a modem for sending and receiving data messages between said communications system and an RF port, the RF port comprising a data interface coupled to said modem, a data processor and an RF module, said data processor being programmed to receive data messages from said modem, to format said messages for wireless data communications and to provide said formatted messages to said RF module for transmission by RF data signals to at least one mobile unit via at least two wireless local area subnetworks occupying common physical space, and to receive RF data signals from said at least one mobile unit via at least two wireless local area subnetworks occupying common physical space, and to provide data messages to said modem to be sent on said communi-



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cations system, wherein said RF port performs low level MAC functions and said communication system performs high level MAC functions.

28. A wireless access device as specified in claim 27 wherein said communications system is a DSL communications system connected to the Internet, and wherein said modem comprises a DSL modem.

29. A wireless access device as specified in claim 27 wherein said communications system is a two-way cable communications system connected to the Internet, and wherein said modem comprises a cable modem.

30. A wireless access device as specified in claim 28 wherein said communication system comprises a fiber optic system, and wherein said modem comprises a fiber optical modem.

31. A method for providing wireless access to the Internet, comprising:

providing a modem coupled to the Internet and having a data communications interface connected to an RF port,

configuring said RF port for wireless data communication to a mobile unit having a predetermined wireless communications address, and

providing at least one mobile unit configured with said predetermined wireless communications address for conducting RF data communications with said RF port via at least two wireless local area subnetworks occupying common physical space, said RF port being arranged to relay communications between said mobile unit and said modem, wherein said RF port performs low level MAC functions and said Internet performs high level MAC functions.

32. The method specified in claim 31 wherein said step of providing said mobile unit, comprises providing a computer having an RF port.

33. A system for providing wireless data communications between mobile units and a wired network operating according to a wireless data communications protocol having high level MAC functions including association and roaming functions, comprising:

at least one RF port performing lower level MAC functions, said at least one RF port having an RF module for sending and receiving data messages to said at least one mobile unit using capable of operating via at least two wireless local area subnetworks occupying common physical space, having a wired interface for sending and receiving data messages to and from said wired network using a wired communications protocol, and a programmed processor for relaying data messages received on said wired interface using said RF communications protocol and for relaying data mes-

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sages received by said RF module using said wired communications protocol; and

at least one cell controller for sending data messages to said wired interface of said RF port and for receiving data messages from said RF port wherein said cell controller performs said high level MAC functions.

34. A system as specified in claim 33, wherein there are provided a plurality of said RF ports, and wherein said cell controller is arranged to address said data messages to said RF ports using said wired communication protocol.

35. A system as specified in claim 33 wherein said at least one mobile unit is associated with one of said RF ports, and wherein said processor is programmed to interpret source address data received in said RF communications protocol and for relaying a received message using said wired communications protocol only if said source address data corresponds.

36. A system as specified in claim 33 wherein said cell controller is arranged to provide messages to said RF port comprising mobile unit address data and message data encapsulated in data packet following said wired communication protocol.

37. A system as specified in claim 36 wherein said cell controller is arranged to provide said mobile unit address data and said message data in said RF communications protocol encapsulated in said wired communication format.

38. A system as specified in claim 33 wherein said RF port is arranged to encapsulate messages received by said RF module in a data packet using said wired communication protocol.

39. The method of claim 1 wherein the cell controller provides extended service set identifiers (ESS).

40. The method of claim 1 wherein the cell controller provides basic service set identifiers (BSS).

41. The method of claim 1 wherein the RF port allocates data bandwidth amongst the service set identifications based on commands from cell controller.

42. The method of claim 1 wherein the RF port generates an 802.11 beacon for each service set identifier.

43. The method of claim 1 wherein the cell controller determines which one of the multiple overlapping wireless local area subnetworks a mobile unit communicating through an RF port is operating on.

44. The method of claim 1 wherein the cell controller verifies levels of security provided in connection with access by mobile units to the multiple overlapping wireless local area subnetworks.

45. The method of claim 1 wherein the cell controller prioritizes communications through the multiple overlapping wireless local area subnetworks.

\* \* \* \* \*

# EXHIBIT B



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**Beach**

(10) **Patent No.:** **US 7,173,923 B2**

(45) **Date of Patent:** **\*Feb. 6, 2007**

(54) **SECURITY IN MULTIPLE WIRELESS  
LOCAL AREA NETWORKS**

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(73) **Assignee:** Symbol Technologies, Inc., Holtsville,  
NY (US)

(\*) **Notice:** Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 883 days.

This patent is subject to a terminal dis-  
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filed on Feb. 9, 2001, which is a continuation-in-part  
of application No. 09/528,697, filed on Mar. 17, 2000.

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*H04Q 7/24* (2006.01)  
*H04L 12/28* (2006.01)  
*H04L 12/56* (2006.01)

(52) **U.S. Cl.** 370/338; 370/401

(58) **Field of Classification Search** 370/401,  
370/338, 466, 419-420

See application file for complete search history.

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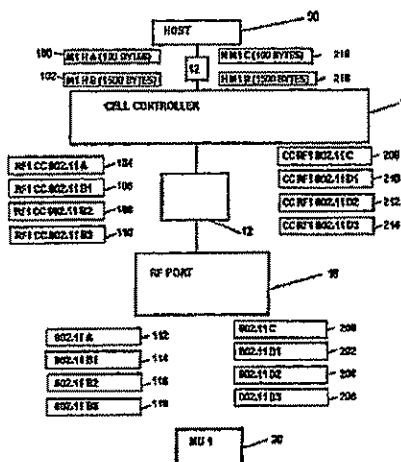
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*Primary Examiner*—Chirag G. Shah  
(74) *Attorney, Agent, or Firm*—Ingrassia Fisher & Lorenz,  
P.C.

(57) **ABSTRACT**

A wireless local area network is provided with simplified RF  
ports which are configured to provide lower level media  
access control functions. Higher level media access control  
functions are provided in a cell controller, which may  
service one or more RF ports that are capable of operating  
based on a pre-assigned security level. Mobile units can also  
be configured with the higher level media access control  
functions being performed in a host processor.

16 Claims, 7 Drawing Sheets



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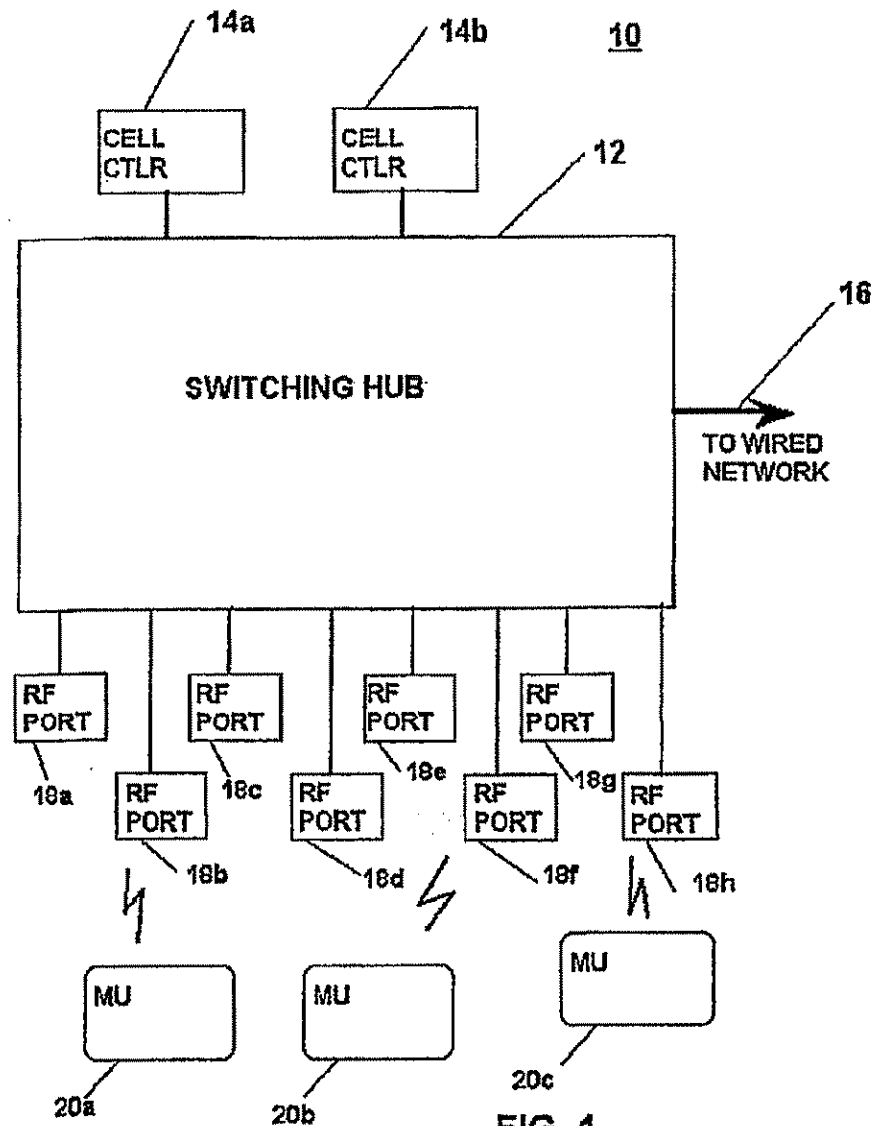


FIG. 1



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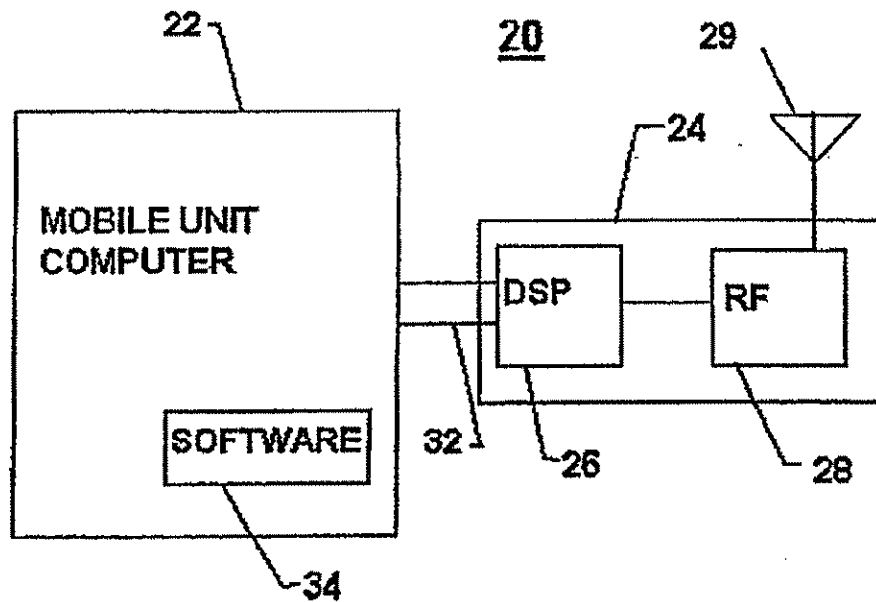


FIG. 2

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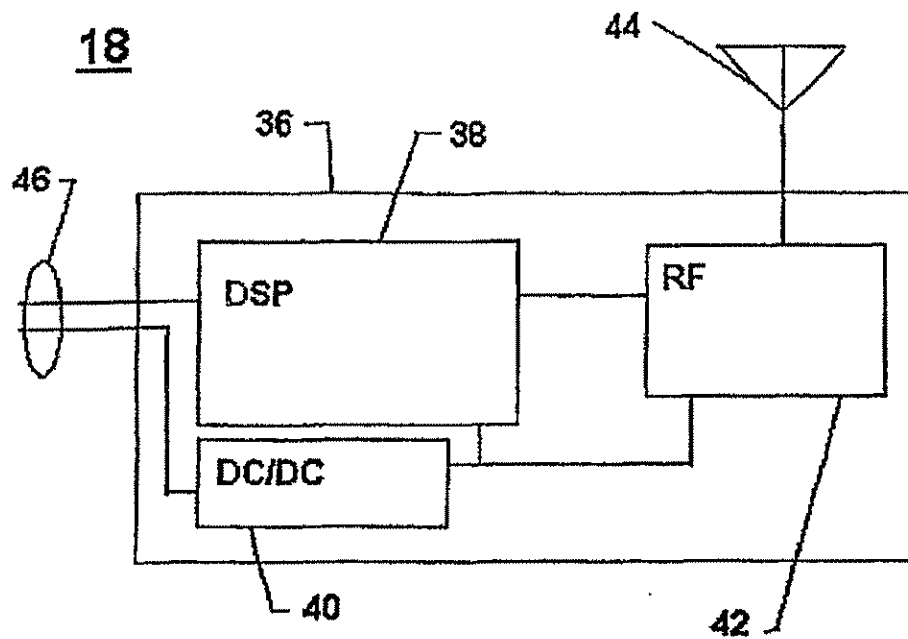


FIG.3

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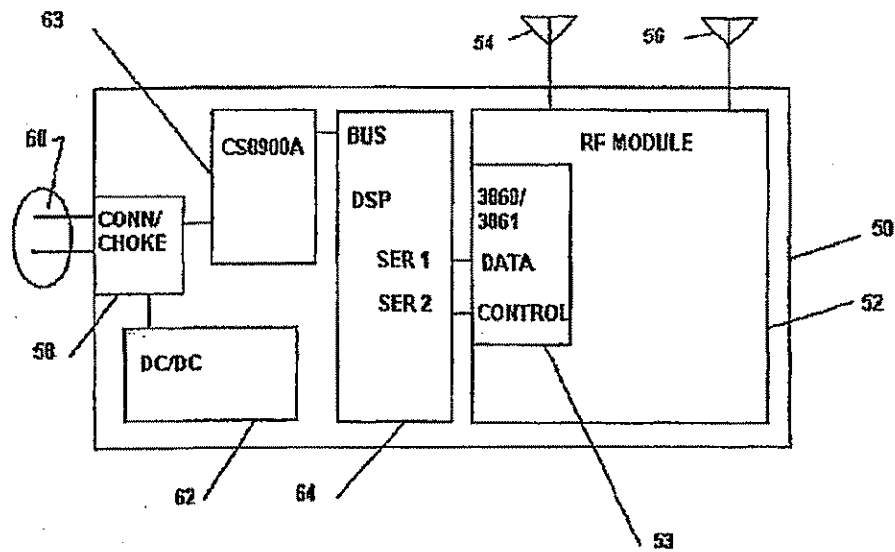


FIG. 4

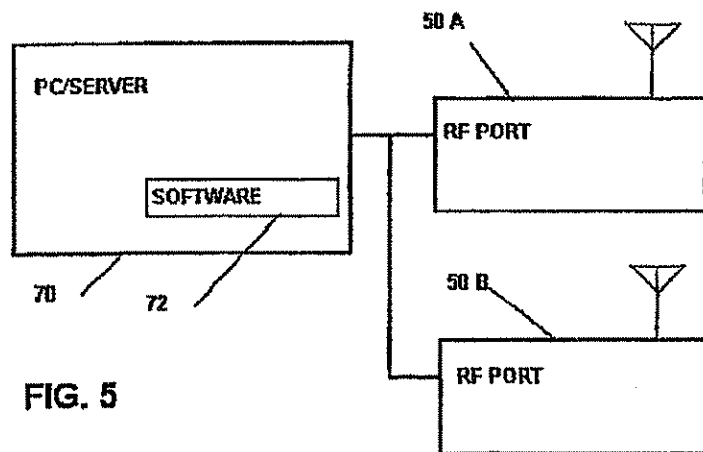


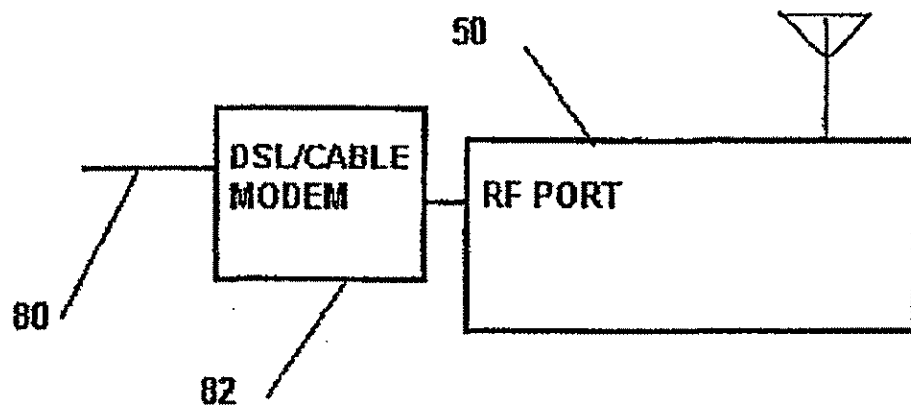
FIG. 5

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**FIG.6**

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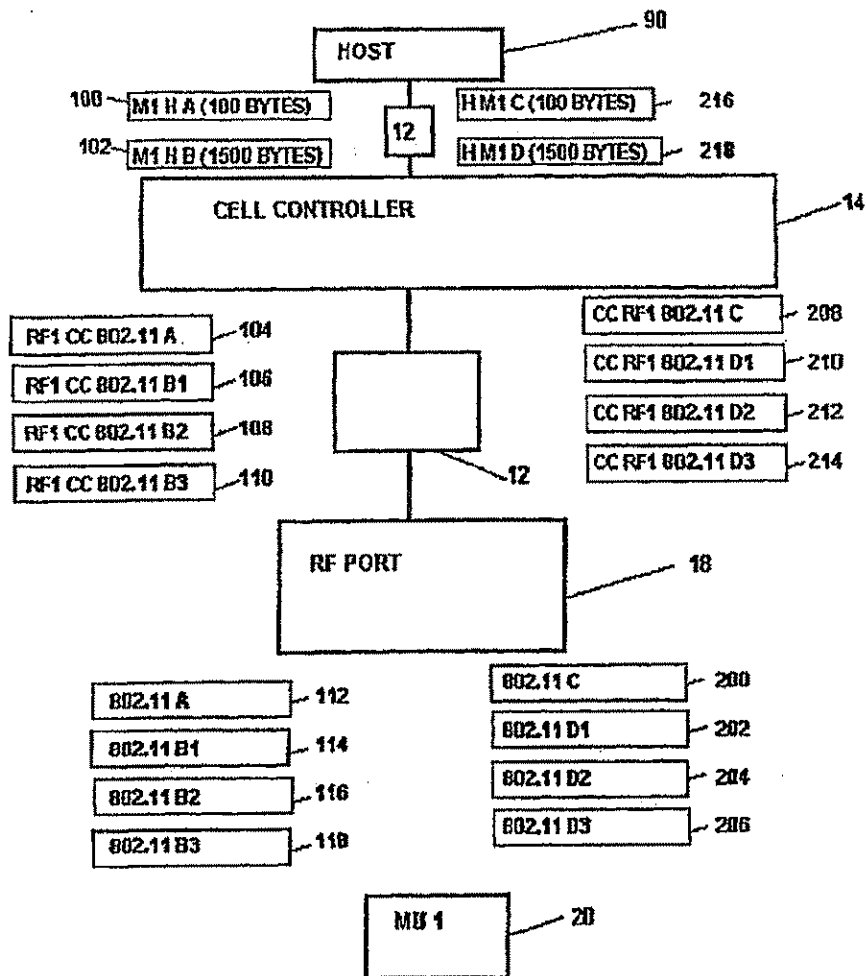


FIG. 7

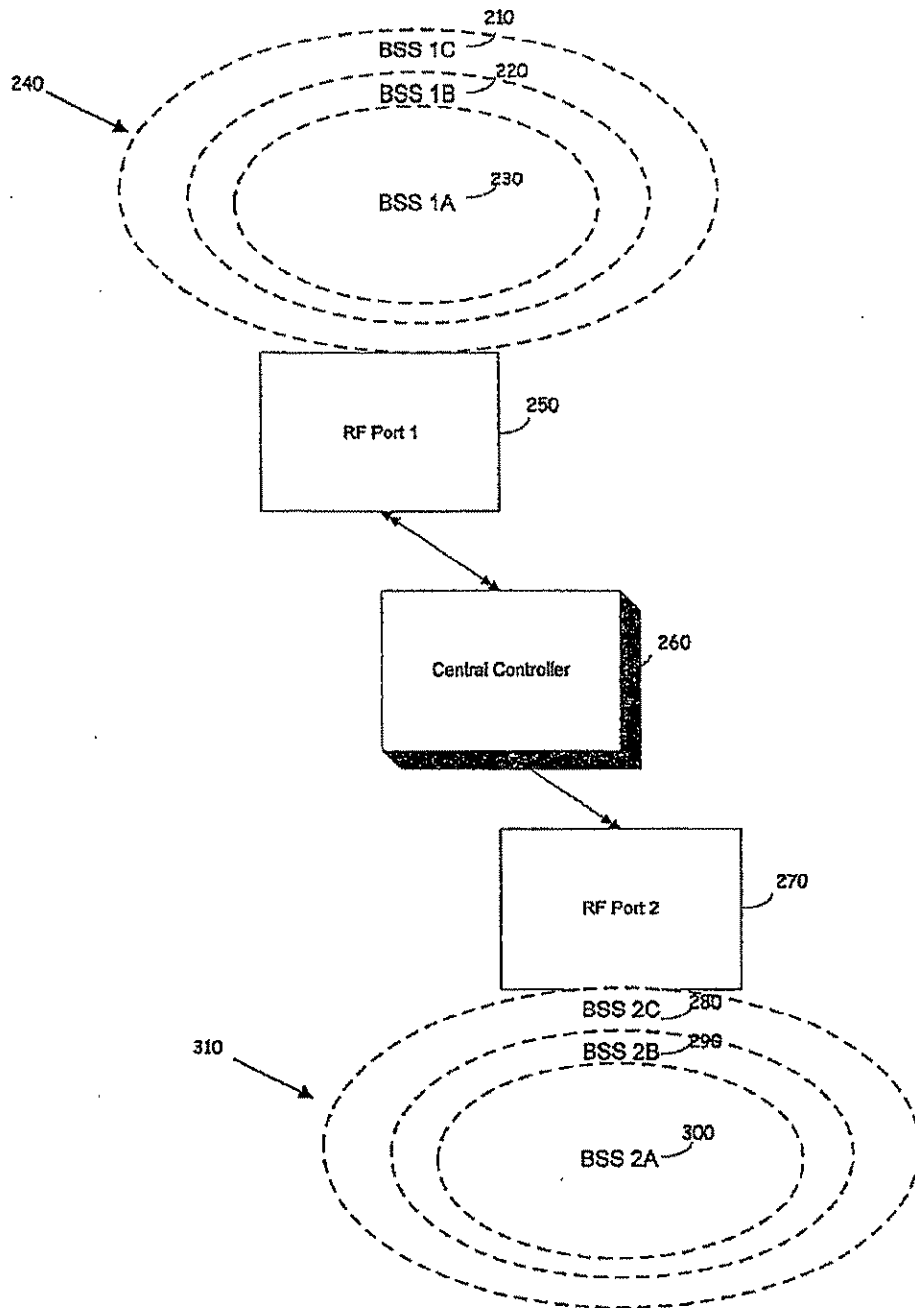
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## FIG. 8



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# 1 SECURITY IN MULTIPLE WIRELESS LOCAL AREA NETWORKS

## REFERENCE TO PRIOR APPLICATION

This application is a continuation-in-part of pending application Ser. No. 09/780,741, filed Feb. 9, 2001, which is a continuation-in-part of pending application Ser. No. 09/528,697, filed Mar. 17, 2000.

## BACKGROUND OF INVENTION

This invention relates to wireless data communications networks, and in particular to arrangements for communications between mobile data handling units and a central computer using wireless data communications.

The assignee of the present invention supplies a wireless data communications system known as the Spectrum 24 System, which follows the radio data communications protocol of IEEE Standard 802.11. In the system as implemented, mobile units are in data communication with a central computer through access points. The access points may communicate with a central computer or computers over a wired network. Each of the mobile units associates itself with one of the access points. The access points in this system are functional to perform all the implemented requirements of the standard protocol, including, association and roaming functions, packet formulation and parsing, packet fragmentation and re-assembly encryption and system access control. In order to maintain order and reduce radio communications each access point must determine which of the data communications received over the wired network from the central computer is destined for a mobile unit associated with that particular access point. This requirement adds significant computational capacity to the access point, increasing the cost thereof.

In addition, in applications that must support a high volume of data communications from multiple users, such as systems supporting a self-service shopping system, hospital systems, systems that include paging or voice data links to many users, or systems supporting communicating with electronic shelf labels, additional access points are required to support the data communications traffic, increasing the overall system cost.

The cost of an operational access point is dependent not only on the complexity thereof and the requirement for high speed processing of data packets for purposes of selecting those destined for mobile units associated with an access point, but the additional cost of the installation of electrical power to the location of the access point, and the cost of a power supply to convert AC electrical power to DC power for the circuits of the access point. Further cost may be involved in physically mounting the access point hardware and antenna.

In prior systems each access point is connected on an Ethernet wired network to the central computer. The access points are required to determine the identity of mobile units which have become associated with them and to extract from the data packets on the Ethernet network those packets addressed to a mobile unit associated with the access point. This requirement has led to significant processing burden for the access points and led to increased cost for the access points.

In the system described in my prior published International Patent Application WO 099 37047, published Jul. 22, 1999, the central computer communicates over an Ethernet wired network with an intelligent switching hub. Alternately

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a token ring network can be used. The switching hub determines the destination of each packet and routes packets to an access point if the destination of the packet is a mobile unit associated with the access point. To achieve this function, the hub is an intelligent hub which maintains a routing list of mobile units and their associated access point according to the port of the hub.

In practice, the hub need only maintain a source list for those access points connected to the hub and mobile units associated with the access points connected to the hub. Thus, if a packet is received at a hub over the Ethernet with a destination address which is not associated with that hub, the packet is ignored. The hub will route the packet to an access point only if the destination address of the packet is identified on the list. When a packet is received on a hub port associated with a communications line connected to an access point, the source address is associated with the hub port in the list. The packet is routed either to the Ethernet connection or to another port according to the destination address.

By determining destination address in the hub and maintaining the association of a mobile unit address with an access point connected to a port of the hub in a routing list of the hub, the functionality required of the access points is greatly reduced. The access point acts merely as a conduit sending RF transmissions of packets received on its communication line, and receiving transmissions from associated mobile units and providing Ethernet packets to the hub. In addition, the access point must provide mobile unit association functions and other 802.11 protocol functions, as provided in the Spectrum 24 system, and may also provide proxy polling responses for associated mobile units that are in power saving mode.

The prior system may have a large number of access points, each with a memory containing program instructions for carrying out the various required functions. This distribution of processing makes it difficult to upgrade a system or to provide changes in system configuration because any upgrade or change may require changes to the program code in each of the access points. Such distribution of processing functions also makes system management functions, such as load balancing or access control more difficult.

It is therefore an object of the present invention to provide an improved wireless data communications methods and systems having lower cost, to enable the economical provision of reliable wireless data communications with increased capacity in complex installations or at reasonable cost or simple installations.

## SUMMARY OF THE INVENTION

In accordance with the invention there is provided a system for providing wireless data communications between mobile units and a wired network. The system includes a plurality of RF ports having at least one data interface and arranged to receive formatted data signals at the data interface and transmit corresponding RF data signals and arranged to receive RF data signals and provide corresponding formatted data signal. There is also provided at least one cell controller, arranged to receive data signals from the wired network and to provide formatted data signals corresponding thereto and to receive formatted data signals and to provide data signals corresponding thereto to the wired network, the cell controller controls association of mobile units with one of the RF ports, provides formatted data

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signals for said mobile units to an associated RF port and receives formatted data signals from the mobile unit from the associated RF port.

In accordance with the invention there is provided an improvement in a wireless data communications network coupled to a data processing system, having a plurality of RF ports and mobile units, wherein the mobile units associate with one of the RF data communications ports to conduct data communications with said data processing system. The mobile units are assigned to one of the RF ports by a cell controller, and the cell controller is arranged to receive first data communications from the data processing system and to relay the data communications to an assigned RF port and to receive second data communications from the RF ports and relay the second data communications to the data processing system.

In accordance with the invention there is provided a method for operating a wireless local area network having at least one RF port, a plurality of mobile units and a cell controller coupled to the RF port. The RF is operated port to relay signals received from mobile units to the cell controller and to relay signals received from the cell controller to the mobile units. The cell controller is operated to control association of the mobile units with the RF port, including sending and receiving association signals between the RF port and the cell controller, and to send messages to and from the mobile unit via the RF ports.

In accordance with the invention there is provided an improvement in a mobile unit for use in a wireless data communications system, wherein the unit has a data processor and programs for the data processor and a wireless network adapter having a programmed processor and a radio module. The programmed processor performs first communications processor functions including control of the radio module and the data processor operates under the programs to perform second communications processor functions, including association with a radio access location of the wireless data communications system.

According to the invention there is provided an improvement in a wireless data communications system for providing data communications following a standardized protocol, wherein the protocol includes association of mobile units with radio access locations. At least one RF port is provided at a radio access location, which RF port comprises a radio module and an RF port processor in data communications with a programmed computer. The RF port processor performs first functions of the standardized protocol and the programmed computer performs second functions of the standardized protocol, including the association of mobile units with said radio access location.

According to the invention there is provided an RF port for use in a wireless data communications system comprising a radio module having a data interface and a transmitter/receiver for wireless data communications; and a digital signal processor having first and second data communications ports, random access memory and read-only memory. The second data communications port is coupled to the data interface of said radio module. The read-only memory is provided with a bootloader program for controlling the digital signal processor to load program instructions to the random access memory via the first communications port. According to the invention there is provided a method for operating an RF port having a radio module, a digital processor, random access memory and read-only memory. A bootloader program is stored in the read-only memory. The digital processor is operated to download instructions from a computer to the random access memory using the boot-

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loader program and the RF port is operated under the downloaded instructions to send and receive messages using the radio module.

According to the invention there is provided a method for transmitting signals having a wireless signal format using an RF port having a wired network interface, a data processor and an RF module. Signals are provided to the wired network interface having wireless address data and message data within a data packet addressed to the RF port using a protocol for the wired network. The processor is operated to provide wireless data signals having the wireless signal format for the address data and the message data to said RF module and operating the RF module is operated to transmit the wireless data signals as an RF signal modulated with the wireless signal format.

According to the invention there is provided a method for transmitting signals having a wireless signal format using an RF port having an Ethernet interface, a data processor and an RF module. An Ethernet data packet is provided to the Ethernet interface, the Ethernet data packet encapsulating as data a data message having the wireless signal format. The data processor is operated to provide the data message to the RF module. The RF module is operated to transmit the data message as an RF signal.

According to the invention there is provided a method for receiving signals having a wireless signal format including wireless address data and message data at an RF port having a wired network interface, a data processor and an RF module. The RF module is operated to receive RF signals having the wireless signal format. The data processor is operated to receive wireless data signals from the RF module and provide data signals to the wired network interface comprising a data packet having a source address corresponding to the RF port using a protocol for the wired network, the data packet including the wireless address data and the message data.

According to the invention there is provided a method for receiving RF message signals having a wireless signal format including an address data format and message data using an RF port having an Ethernet interface, a data processor and an RF module. The RF message signals are received in the RF module and provided as data signals to the data processor. The data processor is operated to interpret address data in the data signals and, in dependence on the address data, said message data and said address data is encapsulated in an Ethernet packet, which is provided to the Ethernet interface.

In accordance with the invention there is provided a simplified wireless local area network system including a computer having a data processor and a memory, an RF port having an RF port data processor, an RF module and a data communications interface coupled to the computer. A first program is provided in the memory of the computer for operating the computer data processor to perform first wireless data communications functions, including association with mobile units. A second program is provided for operating the RF port data processor to perform second wireless data communications functions.

According to the invention there is provided a wireless access device for providing wireless access to a communication system. The device includes a modem for sending and receiving data messages on the communications system and an RF port, having a data interface coupled to the modem, a data processor and an RF module. The data is programmed to receive data messages from the modem, to format the messages for wireless data communications and to provide the formatted messages to the RF module for transmission



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by RF data signals to at least one remote station, and to receive RF data signals from the at least one remote station, and to provide data messages to the modem to be sent on the communications system.

According to the invention there is provided a method for providing wireless access to the Internet. A modem having a data communications interface connected to an RF port is connected to the Internet. The RF port is configured for wireless data communication to at least one mobile unit having a predetermined wireless communications address. A mobile unit configured with the predetermined wireless communications address is provided for conducting RF data communications with the RF port. The RF port is arranged to relay communications between the mobile unit and the modem.

The apparatus and methods of the present invention provide RF ports as radio access locations which are less expensive than known access points and provide greater system management and flexibility. Much of the software used for controlling communications to and from mobile units is performed in a controller wherein software upgrades and changes are easily implemented. According to some embodiments, wherein instructions are downloaded to RF ports, it becomes easy to upgrade RF port instructions. System control is centralized, making management easier and enabling changes to access control and encryption functions. Priority for traffic purposes can also be established to facilitate digital telephony by giving priority to voice traffic. Accordingly, a system is provided that has significant flexibility using common RF port hardware to provide a wireless LAN having from one to hundreds of radio access locations.

According to the invention, the same RF port may provide multiple ESS identifications such that each ESS identification is associated with a separate virtual wireless local area network having its own policies and security.

For a better understanding of the present invention, together with other and further embodiments thereof, reference is made to the following description, taken in conjunction with the accompanying drawings, and its scope will be pointed out in the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a wireless communications system in accordance with the present invention.

FIG. 2 is a block diagram illustrating one example of a mobile unit arranged to be used in the system of FIG. 1.

FIG. 3 is a block diagram illustrating one example of an RF port for the system of FIG. 1.

FIG. 4 is a more detailed block diagram of a preferred embodiment of an RF port in accordance with the invention.

FIG. 5 is a block diagram of an arrangement of a computer and RF port for providing a simplified wireless local area network according to the present invention.

FIG. 6 is a block diagram of an arrangement for providing wireless access to the Internet using the RF port of the present invention.

FIG. 7 is a diagram showing signal format according to one embodiment of the invention.

FIG. 8 is a diagram showing an compilation of RF ports having multiple ESS arrangements for providing overlapping, multiple wireless networks.

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#### DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown an example of a wireless data communications system 10 according to the present invention for providing data communications between a central computer or a collection of computers on a wired network 16 and a plurality of mobile units 20. While prior systems used access points at each radio access location, where the access points are capable of managing wireless communications with mobile units, the system of FIG. 1 uses simplified RF ports 18 at each radio access location to provide radio packet communications with the mobile units 20 using a wireless communications protocol, such as IEEE Standard 802.11, whereby the radio modules in the mobile units 20 monitor polling signals from the RF ports 18, which are originated by the cell controllers 14 and associate with an RF port 18 for purposes of data communications. The system arrangement of FIG. 1 is especially effective in a large wireless local area network (LAN) system wherein it may be necessary to provide a large number of radio access locations. Typically such systems, operating at low power microwave frequencies, require radio access locations at about every 100 feet. Where the wireless LAN system must operate with mobile units, for example, portable computers or similar devices, located throughout a large facility, such as a business, hospital complex or university campus, many such radio access locations may be required, possibly several hundred. Accordingly there is an incentive to reduce the cost of the installation at each radio access location. According to the present invention the system configuration and operation are redesigned to reduce the cost of each individual radio access point. In addition, the system of the present invention provides a concentration of operational control in one or more central controllers 14, making management of the system easier and making modifications and upgrades easier to install.

According to the invention, much of the functionality of the 802.11 protocol associated with the conventional access point, is removed from the device located at the radio access location and provided in a cell controller 14, which may be located in conjunction with a switching hub 12, connected to the wired network 16, with which the wireless network 10 is associated. In particular the usual "access point" device is replaced with a simpler device 18, herein referred to as an "RF port" which contains the RF module, which may be the same RF module used in the prior art access point, and simplified digital circuits to perform only a limited portion of the 802.11 media access control (MAC) functions performed by the prior art access point. In particular the RF port 18 preferably performs only functions of the access point that require a lower level of processing resources in terms of processor capacity and software complexity (memory requirement), and which are time critical. Other functions that are more processor intensive and require more complex programming, and which are not time critical, are relegated to one or more "cell controllers" 14, which may perform these more complex functions for a plurality of RF ports 18.

In order to perform the higher level processing functions of the access point in the cell controller 14, according to the present invention, all messages directed to or from mobile units 20 associated with a particular RF port 18 are processed in a cell controller 14. A system may have one or more cell controllers, which may comprise, e.g. Pentium-type board level computers, each of which is arranged and programmed to handle data message traffic and mobile unit associations for a selected plurality of RF ports 18. A

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switching hub 12 may be interposed to provide message switching among the wired network connected to communications line 16, RF ports 18 and cell controllers 14. Each of the one or more cell controllers 14 acts as a virtual "access point" for traffic addressed to its associated RF ports 18 and to the mobile units 20 associated with those RF ports. When a message is addressed to a mobile unit 20 is received on line 16, switching hub 12 directs the message to the appropriate cell controller 14, which reformats the message and relays the message to the appropriate RF port 18, again through switching hub 12. When the message is received by an RF port 18, it is converted to a radio message and sent to the mobile unit 20 with a minimum of processing.

Likewise, when a message is received from a mobile unit 20 by an RF port 18, it is converted to a digital message packet and relayed to the cell controller 14 associated with the RF port 18 through the switching hub 12. The cell controller 14 passes the message for further relay in the system.

An important feature of a preferred embodiment of the invention is the fact that mobile unit association with the RF ports 18 is a function handled by the cell controller 14. Accordingly, when a mobile unit 20 first becomes active, it sends an association request signal in response to a beacon signal sent by an RF port 18 (in response to direction by the cell controller). The association request signal is relayed by the RF port 18 to the cell controller 14, which performs the processing required for association, including consideration of RF port loading. Cell controller 14 generates appropriate response signals to be sent by the RF port 18 to the mobile unit 20. The cell controller 14 is in an appropriate position to evaluate the loading of the RF ports 18 under its control, and may therefore easily perform load leveling functions, for example, by providing a message to RF port 18 accepting or declining an association request. In addition, the cell controller 14 may receive load messages from other cell controllers 14 in the system 10 and thereby coordinate overall load management. As a mobile unit 20 moves from a location serviced by one RF port 18 to a location serviced by a different RF port 18, the cell controller 14 receives information from the mobile unit 20 indicative of its reception of beacon signals from the various RF ports in the system and performs the necessary functions to support roaming of mobile unit 20.

While in the system 10 of FIG. 1 the cell controllers 14 are shown as separate computers connected to switching hub 12, the term "cell controller" is intended to refer to the logical functions performed by these computers rather than the computers themselves. As will become apparent, the cell controller may be implemented in a variety of ways other than as shown in the exemplary system 10 of FIG. 1.

Implementation of a simplified RF port is achieved by performing "higher level" functions of the 802.11 protocol Media Access Control (MAC) in the cell controller and performing "lower level" functions in a simplified RF port.

The lower level functions are those that are hardware intensive and often time critical. The higher level functions are those that are software intensive and not time critical. One possible division of the exemplary 802.11 MAC functions is as follows:

Lower Level Functions (preferably to be performed at RF port)  
 Cyclic Redundancy Check (CRC)  
 Network Activity Vector (NAV)  
 Ready to Send/Clear to Send (RTS/CTS)  
 Header generation/parsing  
 Collision Avoidance

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Frequency Hopping  
 Ack parsing/generating  
 Retransmission timeout  
 Higher Level Functions (preferably to be performed at Cell Controller)  
 Association processing  
 Roaming  
 Retransmission  
 Rate Control  
 Host Interface

The following optional (higher or lower) level MAC functions can be placed in either the higher or lower level categories.

Wired Equivalent Privacy encryption/decryption (WEP)  
 Fragmentation/Reassembly  
 Data Movement  
 Power Save Polling Support (PSP)

According to a preferred arrangement of the system of the invention, the lower level MAC functions are provided at the RF port, the higher level MAC functions are provided in the cell controller and the optional level functions can be provided at either the cell controller or the RF port.

A major advantage of the invention is a cost savings in hardware, processor capacity and storage capacity for the RF port. Since a system with, for example, one hundred or more radio access locations may be implemented with one or two cell controllers, the processor hardware and memory required for the higher level MAC functions need be provided only at the cell controllers. In fact, the capabilities of the overall system, for WEP encryption and other special functions, can be increased at modest cost by using a high performance board level personal computer or even a host computer as a cell controller.

By eliminating the higher level MAC functions from the radio access locations, the cost of the devices installed at those locations can be significantly reduced because of lower processor capacity and storage.

In connection with association and roaming functions the RF ports 18 provide beacon signals in response to commands generated by the cell controller 14. When an association sequence is initiated by a mobile unit, the RF port 18 relays the association messages between the mobile unit 20 and the cell controller 14 during the association process, which is handled by the cell controller 14.

In connection with message traffic to a mobile unit 20 from a network processor, message packets are routed by switching hub 12 to the cell controller 14 responsible for the mobile unit 20 addressed. The message is buffered and formatted by the cell controller 14 and in a preferred arrangement encapsulated by the cell controller 14 as a mobile unit packet within a wired network packet addressed to the responsible RF port 18. This packet is routed to the RF port 18. The RF port 18 extracts the mobile unit packet from the message and sends the packet to mobile unit 20 as a radio signal. The RF port 14 may also provide a CRC calculation and generate CRC data to be added to the message. The mobile unit 20 responds with an acknowledgment signal to the RF port 18, which generates and sends an acknowledgment status message to cell controller 14.

In connection with messages for systems connected to the wired network 16, the mobile unit 20 sends a packet to the RF port 18 by radio signal. The RF port 18 filters received radio message packets according to the BSS (Basic Service Set) identifier in the packet and, if the packet has a BSS identifier associated with the RF port 18, performs the CRC

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check as the packet is received. The RF port 14 then generates and sends an acknowledgment signal to the mobile unit 20 and sends the received packet to cell controller 14. Cell controller 14 buffers, parses and, if necessary, decrypts the packet and routes the packet to the host on network 16 through hub 12.

The arrangement of RF port 18 may be identical to current access points used in the Spectrum 24 system with some of the access point software non-functional. Preferably the RF ports are simplified to reduce cost and power consumption. To reduce installation expenses the RF ports are powered via an Ethernet cable, which also connects RF ports 18 to switching hub 12 or to cell controller 14. The RF ports can be arranged in a small package (e.g. portable radio size) with integrated diversity antennas and arranged for easy mounting, such as by adhesive tape or Velcro. Connection to the switching hub 12 is by Ethernet cable which is also provided with D.C. power, such as by use of a choke circuit, such as Pulse Model PO421 as described in my referenced International Application. The choke circuit may be built into an Ethernet connector and is available in this configuration.

The RF port 18 does not have to perform Ethernet address filtering and does not have to perform 802.11 association and roaming functions and can therefore have a lower level of processor capacity, software support, memory and power consumption. In one embodiment shown in FIG. 3 the RF port 18 includes only a digital signal processor (DSP) 38 which includes internal RAM and ROM. The DSP 38, which may be one of the Texas Instruments TMS 320 family of DSP processor, such as the 5000 series, specifically the TMS 320 UC 5402 or the TMS 320 VC 5402. This DSP provides an interface between the Ethernet cable 46 and the RF module 42 in RF port 18, as shown in FIG. 3. The RF module 42 is provided in housing 36 with DSP 38, DC/DC power supply 40 and carrying one or more antennas 44. RF module 42 includes a 3860 or 3861 baseband processor, such as HFA 3860B, to interface with the digital portion of the RF port 18, specifically DSP 38. In one arrangement the ROM memory of the DSP 38 can be provided with "bootloader" firmware that downloads the necessary DSP software instructions from the cell controller 14 upon startup of the RF port 18, and loads the instruction into the RAM of the DSP 38.

The processors that are currently preferred as a possible lower level MAC engine are the TMS320UC5402 and the TMS320VC5402. These parts are functionally identical except for differences in power consumption (the VC5402 is currently in production and while the UC5402 is still being sampled). The basic configuration of the UC5402/VC5402 is:

- 100 MIPS execution mtc
- 8 KB on chip ROM (organized as 4Kx16 bits)
- 32KB on chip RAM (organized as 16Kx16 bits)
- Two 16 bit timers with 1  $\mu$ s or better resolution
- Two High speed, full duplex serial ports (up to 50 Mbits/sec each) with smart DMA channel support
- One High speed 8 bit wide host/parallel port (160 Mbit/sec)
- Six DMA channels for general purpose use
- 16 bit external memory/IO Bus with internal wait state generation
- 16 interrupts with 3 instruction (30 ns) worst case latency
- 0.54 mW/MHz power consumption (30 mA@1.8 v at 100 MHz)
- Low Power Modes (6 mA, 2 mA, 2  $\mu$ A depending on setting)

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Internal PLL that generates the system clock with an external crystal

This section will describe the use of a 5402 DSP 38 as a MAC engine for 11 Mbit/sec 802.11 DS systems. It could clearly be used in FH systems as well. We will focus on the how the 5402 interfaces to the Intersil 3860/1 baseband processor in RF module 42 and how it implements the lower level MAC functions.

The first issue is how the 5402 DSP 38 interfaces to the 3861 (much of what is said applies to the 3860 as well) and the rest of the RF module 42. As shown in FIG. 4, the 3861 processor 53 in RF module 52 of RF port 50 has 2 major interfaces, both serial. The first interface, labeled DATA, is used to transfer data between the MAC engine comprising DSP 64 and the 3861. It has four lines: TxID, TxC, RxID, and RxC and operates at up to 11 Mbits/sec. The exact rate depends on the transfer rate of the packet. The clock signals of both interfaces are generated by the 3861 and so transfers are controlled by the 3861. Both can be halted at any time by the 3861 as well as change rate. The second serial interface, labeled CONTROL is used to load commands into the 3861 and read status information from the 3861. This interface is a 4 wire bi-directional interface using one data line, one clock line, one "direction control" line, and a chip select line. This serial interface also can operate at up to 11 Mbits/sec. In addition to the serial interfaces, there are additional control and status lines such as Reset, TX\_PE, RX\_PE, TX\_RDY, etc.

The 5402 DSP 38 has two sets of full duplex serial interfaces that are capable of operation up to 50 Mbits/sec (given a 100 MHz clock). They can be clocked using internal or external sources. In this design one of the sets of serial interfaces, labeled SER1, is used to connect to the high speed data lines of the 3861 interface 53. The 5402 DSP 38 interfaces have the same basic lines (RxID, RxC, TxID, TxC) as does the 3861 and so they connect with minimal trouble. Although the 5402 uses 1.8 v for its core, its I/O lines are 3.3 v tolerant and so can interface to the 3861 without converters. In addition, they are fully static and so can deal the start/stop operation of the clock lines from the 3861.

Data transfer will be done under DMA control within the 5402 using what TI calls "Auto Buffering Mode." This provides essentially dedicated DMA channels for each serial port interface (two DMA channels per serial port interface). These channels access an independently operating bank of SRAM and so transfers have no impact on CPU performance. The CPU can start transfers in either direction and be notified via interrupt on their completion.

Interfacing to the control serial port on the 3861 interface 53 can be done in three different ways. The first, illustrated in FIG. 4, utilizes the second serial port, labeled SER 2 on the 5402 DSP 64 with a small amount of combinatorial logic/buffering to convert between the single data line of the 3861 and the dual data lines of the 5402. Another approach is to use an external shift register that would perform serial/parallel conversion. This register would sit on the I/O bus of the 5402 and would be loaded/read by the 5402 and data shifted between it and the 3861. The third approach is to use an external buffer/latch on the 5402 I/O bus and "bit bang" the clock/data lines to the 3861. The second or third approaches free up the second serial channel for more other use such as providing high speed serial interfaces such as Ethernet or USB and in some applications would be preferred over the first. All require a small amount of external combinatorial logic and so the cost of all solutions is about the same.



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The same logic would apply to interfacing to the synthesizer. It is accessed even less often than the control port of the 3861 and so a "bit banging" approach would work fine.

Finally, interfacing to the various control and status lines presented by the 3861 can be done via simple bidirectional register/latch connected to the I/O bus of the 5402. The 5402 can read/write this register as it needs to control and monitor the 3861. It would be possible to combine all control/monitor functions (including the serial control interface) into a single 16 bit buffered register latch. Parallel control/status lines would be connected to particular lines of this latch. Serial control interfaces would also be connected and "bit banded" as necessary to move data between the 5402 and 3861.

The arrangement shown in FIG. 4 uses a Crystal CS 8900 A Ethernet controller 63 coupled to the parallel port of DSP 64 to interface to the Ethernet port 58. An Ethernet connector/choke 58 receives cable 60 and provides DC power from cable 60 to DC/DC power supply 62. The FIG. 4 RF port 50 includes spaced diversity antennas 54, 56 to improve reception in multipath conditions.

A premise of this design is that the TI DSP is capable of implementing all lower level MAC functions without external hardware assistance. This, of course, is the most demanding model but we will find that the 5402 is up to the task. The most computational demanding tasks are the CRC-32 and WEP processing. The CRC-32 calculation is performed over the entire packet and must be completed in time to generate an ACK should the CRC turn out to be correct (or to attach the calculation result to an outgoing packet on transmission). This means that the CRC calculation must be performed in near real-time during packet transfer between the 3861 and 5402. TI has shown in an application note that a CRC-32 calculation can be made by a 5000 series DSP in 13 instructions. At 100 MIPS this is about 130 ns. At 11 Mbit/sec, a byte takes about 770 ns to transfer and so we have plenty of time to do the CRC. When receiving a packet, the serial port would be transferring the data from the 3861 to SRAM within the 5402. At the same time the CPU within the 5402 would be reading each received byte from SRAM and calculating the CRC. It would of course have to make sure that it did not overrun the receive buffer, but that would be a relatively simple task. Much the same process would happen during transmission. In either case, the CPU has lots of time to do the CRC.

The WEP processing if performed in the RF port 50, is a harder function to perform than CRC-32 since it includes both an RC4 encryption function and a second CRC-32. At the same time it does not need to be completed prior to ACK generation/reception nor is performed on every packet (just data packets). The RC4 encryption function consists of two parts: building the encryption table (a 256 byte table) using the selected key and doing the encryption/decryption process. Based on sample code, it is estimated that building the table would require about 1200 instructions (12 ms at 100 MIPS) and the encryption/decryption process would require about 12 instructions/byte. There is no difference in this cost for 40 or 128 bit keys. The WEP CRC-32 would require another 13 instructions per byte.

The per byte computational burden for WEP would thus be about 25 instructions or about 250 ns at 100 MIPS. When added to the packet CRC-32, the total load would be around 38 instructions/byte. As we pointed out, at 11 Mbit/sec we have about 77 instructions/byte available, so we are spending about 50% of the CPU on CRC/WEP tasks. The biggest issue is the 1200 clocks (12 us) required to build the encryption table during receive (For transmission, the cal-

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ulation can be done prior to starting packet transfer). Pausing to create the table would put the CPU about 18 bytes (12 us at 770 ns/byte) behind in the CRC/WEP/CRC calculation process. It would require about 40 data bytes to catch up (1200 clocks/30 extra clocks per byte) in both packet CRC and WEP/CRC functions. Since the minimum TCP/IP header is at least 40 bytes (plus any user data), we should have enough time. In any case if we are a little late in WEP/CRC calculation, no harm is done. An alternative approach would be to catch up first for the packet CRC calculation and then catch up with WEP/CRC.

After CRC and WEP/CRC processing, the next most critical activity is header parsing on receive and generation on transmit. This is because of the need to identify packets for the station and generate appropriate responses. On receive, the processor must parse two or three 48 bit addresses and at least a 16 bit header command field. After the packet completes, an ACK may need to be generated.

The 5402 can easily handle these functions. Since these functions are performed prior to WEP processing, the CPU has 64 instructions/byte (77—13) to perform these functions. Since many of them can be performed on a 16 bit or even 32 bit basis (the 5402 supports both 16 and 32 operations), there may be up to 128 or 256 instructions per data item (i.e. 256 instructions to perform a 32 bit address check). These functions are performed at 2 Mbit using a 1 MIPS 188 CPU. We have a 100 MIPS CPU to do the same tasks at 11 Mbit/sec.

ACK generation is likewise relatively simple. An ACK frame is only 14 bytes long, including the 4 CRC-32. Given there is a long (80 us) preamble, we have 8000 instructions to prepare the ACK. The same applies to RTS/CTS exchanges.

There are two 16 bit timers available on the 5402. In this model, one would be used for TSF timing and the other for all other functions. There are really only a few other timer functions: NAV, Retransmission, collision avoidance slot countdown, etc. Retransmission and collision avoidance activities go on only when waiting for an ACK or to start a retransmission after detection of an idle network. In such cases there is no data transfer going on and so there is lots of CPU cycles available.

Support for MU PSP function can be done in a variety of ways, depending on how much, if any, external hardware is provided. The 5402 provides a variety of means of conserving power. The first is simply to slow down the CPU clock via the software controlled PFI within the unit. The 5402 generates internal clocks via a PLL that is driven by either an external crystal or clock. The PLL multiplies the base frequency of the crystal/external clock by a factor determined by software. Hence one means of controlling power consumption is simply to slow down the CPU clock. Since the CPU portion of the processor consumes most of the power, slowing it down has the biggest affect on power consumption.

The second approach is use one of the IDLE modes of the processor. IDLE1 stops the CPU clock entirely but leaves everything else running. Power consumption in this mode is on the order of 6 mA at 100 MHz. The CPU can be restarted by any interrupt (internal or external). In IDLE2 the system clock is stopped and this reduces consumption to 2 mA. In IDLE3, all system functions are stopped and consumption is reduced to around 2 ua. In all cases all state is retained. In IDLE2 and IDLE3, an external interrupt is required to restart the CPU. In such cases an external, low power timer would be required.

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Thus with no external hardware, power consumption could be reduced to at least 6 mA and perhaps less. With a simple external timer, one could get down to microamps.

The bottom line is that the vast CPU power of the 5402 allows all lower level MAC functions to be performed in software. Furthermore it has sufficient power and memory to handle additional "higher level" functions such as packet retransmission, fragmentation, and reassembly that can also be done in a cell controller.

The system 10 of the present invention is compatible with IEEE Standard 802.11 and accordingly will operate with any mobile units 20, including existing units, which are compatible with the same standard. However, the improvements applied to the RF ports 18, reducing the complexity and cost of these units can also be applied to the mobile units 20, which have sufficient main processor capacity to handle the mobile unit functions corresponding to the higher order MAC functions.

Referring to FIG. 2 there is shown a block diagram for a mobile unit 20 having a mobile unit computer 22 and a WLAN adapter 24 connected thereto to provide wireless communications to the system 10 of FIG. 1. In the mobile unit 20 of FIG. 2, the lower level MAC functions are performed in WLAN adapter 24, which also includes RF module 28 and antenna 29. The configuration of WLAN adapter 24 may be similar to existing adapters, but preferably adapter 24 is simplified to perform only the lower level MAC functions of the IEEE 802.11 protocol and allow special software 34 in host computer 22 to perform the higher level MAC functions, such as association and roaming. In a preferred arrangement the MAC functions of adapter 24 are performed in a digital signal processor 26, as described below, which may be the same type DSP described with respect to RF port 50.

This section addresses how the 5402 DSP could be used as a MAC engine in Mobile Unit configurations. There are two considerations in building MU WLAN solutions. The first is the location of those MAC functions, while the second is the physical interface to the host.

The location of the upper level MAC functions may vary considerably. Some possibilities are:

All functions on MAC engine DSP processor 26

All functions on host processor 22

Roaming/association on host processor 22, rest on MAC engine 26

Roaming/association/retransmission on host 22, rest on MAC engine 26. The choice of the location of the higher level MAC functions has a major impact on the cost of MU WLAN adapter. If one is willing to place at least some of the higher level functions on a host processor 22, then one could get by with just the 5402 on the WLAN adapter. Possible functions to place on the host would be roaming and association control. Higher level functions such as retransmission and fragmentation/reassembly could be left on the 5402. This split would permit significant savings, since another processor/memory subsystem would not be needed on the WLAN adapter. There are two reasons for not placing all of the MAC functions on the 5402. The first is memory space on the 5402 is only 32KB of SRAM for both code and data. In some MAC implementations such as frequency hop, the code space alone exceeds 32 KB. The second reason is that the software on the 5402 is oriented toward meeting hard, real-time tasks such as CRC and WEP processing. Trying to add software intensive tasks would only complicate the process.

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If another processor was required, such as an ARM or perhaps a second 5000 Series processor, the upper level functions could be added to it.

Alternatively one could place all the MAC functions on a faster and/or bigger version of the 5402 processor. Such a processor would likely have a higher clock rate (current members of the 5000 Series can be clocked as high as 160 MIPS) and more memory (say 64 KB instead of 32KB).

Both the second processor as well as a faster/bigger 5402 would consume additional power as well as adding cost.

This section will describe one approach of how a MU WLAN adapter can be arranged for various hardware host interfaces using the 5402. It assumes that enough of the upper level MAC functions have been offloaded to a host processor so that only the 5402 is required on the WLAN adapter. A second processor could be added to any of the solutions outlined below.

In all of the following solutions, it is assumed that the runtime code for the 5402 is loaded from an external source (such as computer 22) via the host interface 32. This eliminates the need for flash memory on the adapter card, saving several dollars in the process. It should be pointed out that the 5402 comes with 8KB of mask programmable ROM and a bootloader program (required for the USB and Ethernet host interfaces) would be placed in it. The bootloader would be smart enough to download the runtime code instructions over whatever serial interface was available.

The simplest interface of all would be for a host to use the Host Port on the 5402. This port operates as a dual port interface into the memory within the 5402. It would not be a standard interface but would be quite suitable for dedicated systems. Using it, computer 22 can read/write memory on a random or sequential basis. It is an 8 bit interface and can operate as fast as 160 Mbit/sec. When operated in random access mode, the computer 22 generates a 16 bit address using two writes to the port and then performs either a read or write operation. Such a mode allows a host to set up command blocks and the like within the memory of the 5402. Sequential mode allows a host to transfer data in and out of the 5402 memory very quickly (160 Mbit/sec). This would be used for transferring data.

If this approach was used, the only digital component on the WLAN adapter would be the 5402.

In the system of FIG. 1, the cell controller 14 is a board level personal computer coupled to the switching hub 12 preferably by 10 M bit and 100 Mb Ethernet ports. For smaller systems a 350 MHz Pentium computer with 16 MB RAM may be used. For larger systems having many RF ports a 500 MHz Pentium with 64 MB RAM is appropriate. Communications to and from the wired network are preferably carried out at 100 MHz. Communications to and from RF ports may be carried out at 10 MHz. A second cell controller may be supplied for larger systems and/or to provide backup in the event one cell controller fails. Reliability can be enhanced by providing dual fans and dual power supplies. A flash disk memory may be used for reliability. Alternately, the cell controller 14 may be built into the switching hub 12 or into a host processor.

The operating system for the cell controller 14 may be a real time operating system, such as VRTX or QNX, which provides multitasking, a full network stack and utilities. Web based management utilities, which are client side java based, are provided for maintaining the configuration of the cell controller 14, the RF ports 18 and status of the mobile units 20.

The cell controller 14 includes applications to provide mobile unit association management, roaming and packet

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buffer management. These applications are similar to those performed by current access points in the Spectrum 24 system. The cell controller 14 may also provide QoS support, user authorization and configuration management. Placing these functions on a personal computer cell controller facilitates system management and program updates using available programming tools. Further, modifications to authorization or management functions need only be installed into the cell controller 14, and no modification to the software of the RF ports 18 is required.

The cell controllers 14 handle routing of all messages to or from the mobile unit. The cell controller buffers message packets received from the wired network and determines the appropriate RF port 18 with which the addressed mobile unit 20 is associated and sends the packet to the RF port 18. The cell controller 14 can additionally perform WEP encryption/decryption and the CAC associated therewith.

The cell controller 14 may also the additional function of maintaining and downloading firmware to the RF ports 18. Upon power up the RF ports 18 use a boot loader routine stored in ROM to send a download request to cell controller 14. The cell controller then downloads firmware to the RF port 18, including configuration information such as channel assignment, ESS and BSS identification. The cell controller 14 and RF ports 18 additionally share a common TSP clock.

The mobile unit computer 22 of mobile unit 20 is provided with similar software to perform the higher level MAC functions as outlined above. Advantageously, the software 34 can be programmed using the same operating system as provided for the computer, and thereby provide a user interface, such as Windows, which is familiar to the user. The mobile unit software 34 provides the MAC functions of header building, roaming and association. The mobile unit computer 22 may also download firmware to the processor in the WLAN adapter 24.

As evident from the foregoing description, the hardware for RF port 18 and WLAN adapter 24 of mobile unit 20 can be substantially similar, with the possible exception of the interface to an Ethernet network or to a mobile unit host. Further, the logical cell controller function and the higher order MAC functions performed by the mobile unit host processor can be performed on any computer system.

Using the RF port 18 of the present invention coupled to a computer system, it is possible to provide either a mobile unit or a wireless network according to the software provided. Since the software for RF port 18 may be downloaded from a host system a simple combination of a computer and one or more RF ports can function as either a WLAN mobile unit as a WLAN host or both, by providing function selectable firmware to the processor in the RF port.

In the arrangement shown in FIG. 5, a personal computer 70 is provided with software 72 and connected to one or more RF ports 50A, 50B to provide a complete host system for wireless data communications. This arrangement could be used, for example, in a small business wherein office equipment is connected to server 70 by a wired network for conventional LAN operation and one or more RF ports 50 are also connected to server 70 on the LAN system to provide data communications between the server 70 and mobile units. The server can perform the higher order MAC functions and download firmware instructions to the RF ports. Alternatively, the firmware instructions can be installed on PROM memory in the RF ports.

FIG. 6 shows an arrangement for providing wireless access to the Internet using the RF port 50 of the present invention. Internet access over communications line 80 to modem 82 may be provided by cable, DSL or fiber optical transmission. RF port 50 may be provided with MAC firmware on PROM or may be configured with a boot loader

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program to download firmware from an ISP server. When installed in a home or office, mobile units 20 can associate with RF port 50 to initiate Internet access. The ISP server may perform the higher level MAC function, or they may be provided in RF port 50.

The mobile units 20 may be the personal computers 22 in a home or office with a WLAN adapter 24 as shown in FIG. 2.

FIG. 7 illustrates an example of communications formats that might be used in the various system embodiments of the present invention. The FIG. 7 example assumes that the configuration includes a host 90 connected to a dedicated cell controller 14, which is likewise connected to RF port 18. It should be clearly understood that the logical cell controller functions may be performed in host 90, particularly in a simple system.

In the FIG. 7 example host 90 sends message "A" having 100 data bytes via an Ethernet packet 100 to cell controller 14. Packet 100 has a destination address of the Mobile unit (M1), a source address of the host (H) and includes data (A). Cell controller 14 formats the data in 802.11 format with the destination corresponding to mobile unit (MU1) 20. The cell encapsulates this 802.11 packet with data A into an Ethernet packet 104 addressed to RF port 1 (RPT) from the cell controller (cell controller).

RF port 18 receives the Ethernet packet 104 from cell controller 14 and generates and sends an RF packet 112 in 802.11 format to mobile unit 20, including data A. It should be understood that 802.11 header generation can be provided at either the cell controller 14 or the RF port 18, but packet 104 must include mobile unit identification data either as an 802.11 header or otherwise to enable RF port 18 to generate the header. RF port 18 additionally performs the CRC computation and adds the result to the 802.11 packet 112.

A second message "B" having 1500 bytes of data is also shown as originating as Ethernet packet 102 from host 90 to cell controller 14. Cell controller fragments data message B into three fragments B1, B2 and B3 to accommodate the 500 byte data limit of 802.11 packets. These three fragments are sent as Ethernet packets 106, 108, 110 to RF port 18, which transmits RF signal packets 114, 116, 118 to mobile unit 20.

Reverse communication is similar. Message C has 100 bytes and is sent by mobile unit 20 to RF port 18 as 802.11 RF signal packet 200. RF port 18 encapsulates this message into Ethernet packet 208 and sends it to cell controller 14, which extracts the destination information and data to provide Ethernet message 216 to the host 90. A larger message D is sent as message fragments 202, 204, 206 to RF ports 18, relayed as Ethernet packets 210, 212, 214 to cell controller 14 and sent as a reassembled Ethernet packet 218 to host 90.

Referring now to FIG. 8, shown is an application of the central controller/RF port model that may be used to set multiple overlapping BSS LANs for use in the same or overlapping physical space. Shown in FIG. 8 is a central controller 260 which is associated with two RF ports, RF port 1 250 and RF port 2 270. The central controller 260 may be associated with more than two RF ports, but two are shown for illustration purposes. Each RF port 250, 270 provides coverage for a wireless LAN in the physical areas 240, 310.

FIG. 8 further illustrates the concept of providing multiple ESS identifications through the same RF port and cell controller such that each BSS identification is associated with a separate virtual wireless local area network having its own policies and security. Thus, RF port 1 250 may be configured so as to support separate BSS networks 1A 230, 1B 220 and 1C 210, all of which occupy the same physical space 240. The RF port may support more than three BSS networks, but three are shown for illustration purposes. Similarly, RF port 2 270 may be configured so as to support



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BSS networks 2A 300, 2B 290 and 2C 280, all of which occupy the same physical space 310. Using the configuration as shown in FIG. 8, multiple FSS LANs may be coordinated by the central controller 260 in the physical space 240 and 310. FSS A personnel, such as airport employees, may have access to the public level and also have access to the airport operational network. The scenery-based network would be available for select airport personnel such as management and security officers.

The cell controller performs the function of determining which ESS network a mobile unit communicating with an RF port associated with the cell controller is operating on, and thereby controls the direction of communication from the cell controller to the network. The cell controller can verify the multiple levels of security provided in connection with the access by the mobile unit devices, and in addition can prioritize communications so that higher priority communications such as security communications are given greater access to the system during higher traffic conditions. For example, in the three-tier embodiment discussed above, the security network could have a feature to disallow all other network access in an emergency situation.

A similar multi-virtual LAN network may be also useful in a health care facility wherein different networks are used for security, medical care, personal and public information.

The architecture described herein offers advantages in several discrete areas of wireless network management.

#### Bandwidth Management

An aspect of functionality that can be realized in connection with the configuration described herein is to modify the bandwidth of communications in accordance with the type of device with which the communication is associated. For example, where a data set comprises an image, for example retrieved from the Internet, the resolution of the image can be modified in the cell controller to accommodate the resolution capacity of a portable device. Therefore, rather than provide a highly detailed image of the type that can be displayed on a personal computer, an image-bearing message can be reduced in resolution in the cell controller to a lower resolution, compatible with a portable device, such as a personal digital assistant. By therefore reducing the resolution of the image being sent, the bandwidth and data capacity necessary to send the image can be significantly reduced.

Another functionality available with the configuration described herein is to control the individual RF ports according to the traffic experienced by the system. For example, the cell controller can assign an RF port experiencing a high volume of communication to a different channel, such as a reserve channel on which no other RF ports are operating. This will minimize interference in communications conducted with a particular RF port that is experiencing high volume. In this manner the RF port may be the only RF port operating on the particular, reserve channel. The cell controller has real time information available to it in order to make the changes in the RF port configuration to accommodate changing load conditions.

A wireless system may also contain RF ports sending and receiving overlapping 2.4 GHz, Bluetooth, and 5 GHz signals. These signals will have differing frequencies, power levels, and data rates. Because the cell controller will monitor all features of the frequencies generated by the RF ports and will know the locations of the RF ports, the cell controller will have the ability to optimize the frequency, power level and data rates in the physical space for the best possible performance.

The cell controller provides a central location for interfacing the WLAN with WAN features that may be accessed by users. For example, the cell controller can coordinate the processing necessary to enable voice over IP (VoIP), i.e.

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compression or user allocations. Compression is particularly enhanced using a cell controller because the cell controller can maintain the necessary historical dictionaries needed for efficient compression algorithms in one location that applies to all RF ports. The cell controller can also proxy to access a SIM database for WAN users in advance of actually needing this data to perform operations.

The cell controller allows additional functionality to the WLAN at all levels while maintaining the compatibility in the MAC level necessary for IEEE 802.11 systems. One such example would network management features that are not present in the 802.11 protocol but would be useful to operate at the cell controller/RF port level. An embodiment of this is to monitor the software versions present in the MUs in a WLAN and send out updated versions when each MU "checks in" with the cell controller. Ultimately this allows the costs of APs/RF ports to remain relatively inexpensive.

Other aspects of routing traffic through the cell controller is the ability to detect interference and noise and the ability to control the transmit power of particular RF ports. For example, the cell controller can command the RF port to provide the signal level they are receiving when there is no communication (background noise or interference) to the cell controller. This can be used to provide an analysis of the system operation or to provide the detection of background interference and its location.

#### Security

Another available function of this architecture is control of association, since all association is handled in a cell controller. Accordingly, where a "public access only" device attempts to associate with the system in a secure area such as, for example, an airport control tower, where a member of the public should not be, the fact of this association attempt can be noted in the cell controller and automatically give notice to security personnel. The cell controller can additionally deny or permit access to a mobile unit attempting to associate with an RF port according to traffic at the RF port as observed at the cell controller. The cell controller thereby has a measure of control over roaming and can command a mobile unit as to which RF port to become associated with. Indeed, under many WLAN architectures, APs do not coordinate with each other to determine if they are being probed in such a way that an attempt to break security may be occurring. In contrast, a cell controller can monitor all such probing to determine if an attack may be taking place. Logs of such probing may be kept. In addition, authentication protocols may be centralized in the cell controller instead of on a central server, creating greater efficiency.

Another important aspect of control of association and roaming in the cell controller is the fact that the cell controller can perform a "soft-roaming" function. Soft-roaming takes place when the cell controller changes ownership of the BSS identification between RF units. In essence the cell controller has the ability to tell a mobile unit which RF port it will communicate through. In connection with doing so it is possible for one RF port to monitor traffic to another RF port and thereby advise the cell controller that it has the capability of receiving signals from that particular mobile unit. The cell controller has the ability to control the access of the mobile units to RF ports according to traffic as observed in the cell controller. One aspect of the system is that the intelligence in the cell controller interacts with the intelligence in the mobile unit to control association. The RF port has no part in this and accordingly there is a greater ability to centrally managed the flow of traffic through the RF port. Another aspect is to provide an arrangement in the cell controller wherein only one RF port can perform secure data communication. When a mobile unit desires a secure link, the cell controller can switch the mobile unit to a particular RF port for secure communications. In essence the

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unit is capable of providing a virtual RF port. The switching of the BSS identification between RF ports takes place in the cell controller and the mobile unit has no idea that it has been given the bait and switch. Another aspect of the centralized management is security, in that if a mobile unit which does not have access authorization attempts a number of times to gain access to the system, the security program in the cell controller can provide an alert and in essence lock out further attempts by that mobile unit.

#### Location Tracking

In the architecture described herein, because RF ports are cheaper than typical APs, there may be more RF ports in a given area than APs. This proliferation of RF ports will allow location tracking to take place. Moreover, one RF port has the ability to "snoop" and listen in to the traffic between another RF port and a mobile unit. The cell controller can take all this data in and use time stamping based on the arrival of data. Such information can be passed through the Ethernet to a processor that can determine location.

#### Diagnostic Capability

An important capability which the cell controller can also implement is the diagnostic capability. As an initial calibration when a system is first brought into operation the cell controller can cause the RF ports to go through a sequence in which the RF ports communicate to each other. In this way the signal level of each RF port, as observed at one or more other RF ports, can be monitored and the radio location of the RF ports can be mapped, for example, to create alternative RF ports to which traffic can be switched in the event of excess traffic on any particular RF port. Accordingly using RF signals the cell controller can dynamically discover the RF locations and signal characteristics between RF ports. Each RF port in this case would provide the cell controller with an indication of the strength of the signals received. The cell controller can also record the background noise level. Following the initial calibration of the system the cell controller can undertake periodic diagnostics, wherein signals are sent from one RF port to another and the signal level is relayed to the cell controller to determine whether if the transmitters and receivers are operating properly. In this respect, the signals received can be compared to the base line signal levels which have been recorded at the cell controller as a calibration level. Changes in background noise can also be determined and this can be used to detect a problem with a receiver in the system.

While there has been described what is believed to be claimed in the above-identified application those skilled in the art will recognize that other and further modifications may be made without departing from the scope of the invention and it is intended to claim all such changes and modifications as fall within the true scope of the invention.

#### 1 claim:

1. A system for providing wireless data communications between mobile units and a wired network operating according to a wireless data communications standard protocol having high level MAC functions and low level MAC functions, comprising:

a plurality of RF ports configured to perform the low level MAC functions of the wireless data communications standard protocol, the RF ports having at least one data interface and a security status, said RF ports being arranged to receive formatted data signals at said data interface and transmit corresponding RF data signals and arranged to receive RF data signals and provide corresponding formatted data signals; and at least one cell controller separately housed from said plurality of RF ports and configured to perform the high level MAC functions of the wireless data communica-

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tions standard protocol, the at least one controller arranged to receive data signals from said wired network and to provide formatted data signals corresponding thereto to said data interface of said RF ports and to receive formatted data signals from said RF ports and to provide data signals corresponding thereto to said wired network, said cell controller controlling association of mobile units with one of said RF ports based on the security status of the one of said RF ports, providing formatted data signals for said mobile units to an associated RF port, and receiving formatted data signals from said mobile unit from said associated RF port.

2. The system specified in claim 1 wherein the wireless data communications standard protocol is the IEEE 802.11 standard protocol.

3. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a cyclic redundancy check function.

4. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a network activity vector function.

5. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a ready to send/clear to send function.

6. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a header generation/parsing function.

7. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a collision avoidance function.

8. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include a frequency hopping function.

9. The system specified in claim 1, wherein said low level media access control functions performed by said RF ports include an ack parsing/generating function.

10. The system specified in claim 1, wherein said lower level media access control functions performed by said RF ports include a retransmission timeout function.

11. The system specified in claim 1, wherein said higher level media access control functions performed by said cell controller include a roaming function.

12. The system specified in claim 1, wherein said higher level media access control functions performed by said cell controller include a retransmission function.

13. The system specified in claim 1, wherein said higher level media access control functions performed by said cell controller include a rate control function.

14. The system specified in claim 1, wherein said higher level media access control functions performed by said cell controller include a host interface function.

15. The system specified in claim 1, wherein said lower level media access control functions performed by said RF ports includes a cyclic redundancy check function, a network activity vector function, a ready to send/clear to send function, a header generation/parsing function, a collision avoidance function, a frequency hopping function, an ack parsing/generating function, and a retransmission timeout function.

16. The system specified in claim 1, wherein said higher level media access control functions performed by said cell controller include a roaming function, a retransmission function, a rate control function, a host interface function.

\* \* \* \* \*



# EXHIBIT C



US006625454B1

(12) **United States Patent**  
Rappaport et al.

(10) Patent No.: **US 6,625,454 B1**  
(45) Date of Patent: **\*Sep. 23, 2003**

(54) **METHOD AND SYSTEM FOR DESIGNING  
OR DEPLOYING A COMMUNICATIONS  
NETWORK WHICH CONSIDERS  
FREQUENCY DEPENDENT EFFECTS**

(75) Inventors: **Theodore Rappaport, Salem, VA (US);  
Roger Skidmore, Blacksburg, VA (US);  
Eric Reifsnider, Blacksburg, VA (US)**

(73) Assignee: **Wireless Valley Communications, Inc.,  
Austin, TX (US)**

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 299 days.

This patent is subject to a terminal dis-  
claimer.

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Primary Examiner—William Trost

Assistant Examiner—Earl Mooruman

(74) Attorney, Agent, or Firm—Whitham, Curtis &  
Christofferson, PC

#### (57) ABSTRACT

A computerized model provides a display of a physical environment in which a communications network is or will be installed. The communications network is comprised of several components, each of which are selected by the design engineer and which are represented in the display. Errors in the selection of certain selected components for the communications network are identified by their attributes or frequency characteristics as well as by their interconnection compatibility for a particular design. The effects of changes in frequency on component performance are modeled and the results are displayed to the design engineer. A bill of materials is automatically checked for faults and generated for the design system and provided to the design engineer. For ease of design, the design engineer can cluster several different preferred components into component kits, and then select these component kits for use in the design or deployment process.

14 Claims, 22 Drawing Sheets

(21) Appl. No.: 09/633,121

(22) Filed: Aug. 4, 2000

(51) Int. Cl.<sup>7</sup> ..... H04B 17/00

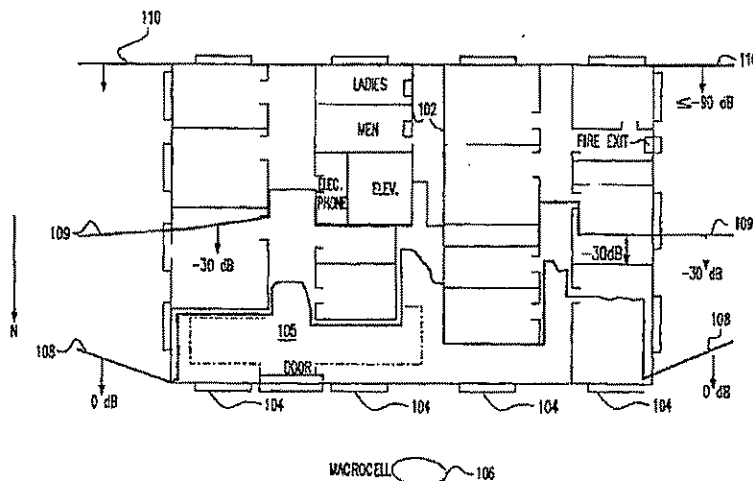
(52) U.S. Cl. .... 455/446; 455/422; 455/423;  
455/424; 455/425; 455/67.1; 703/21; 703/22

(58) Field of Search ..... 455/560, 561,  
455/422, 423, 424, 425, 446, 67.1; 703/2-4,  
21, 22

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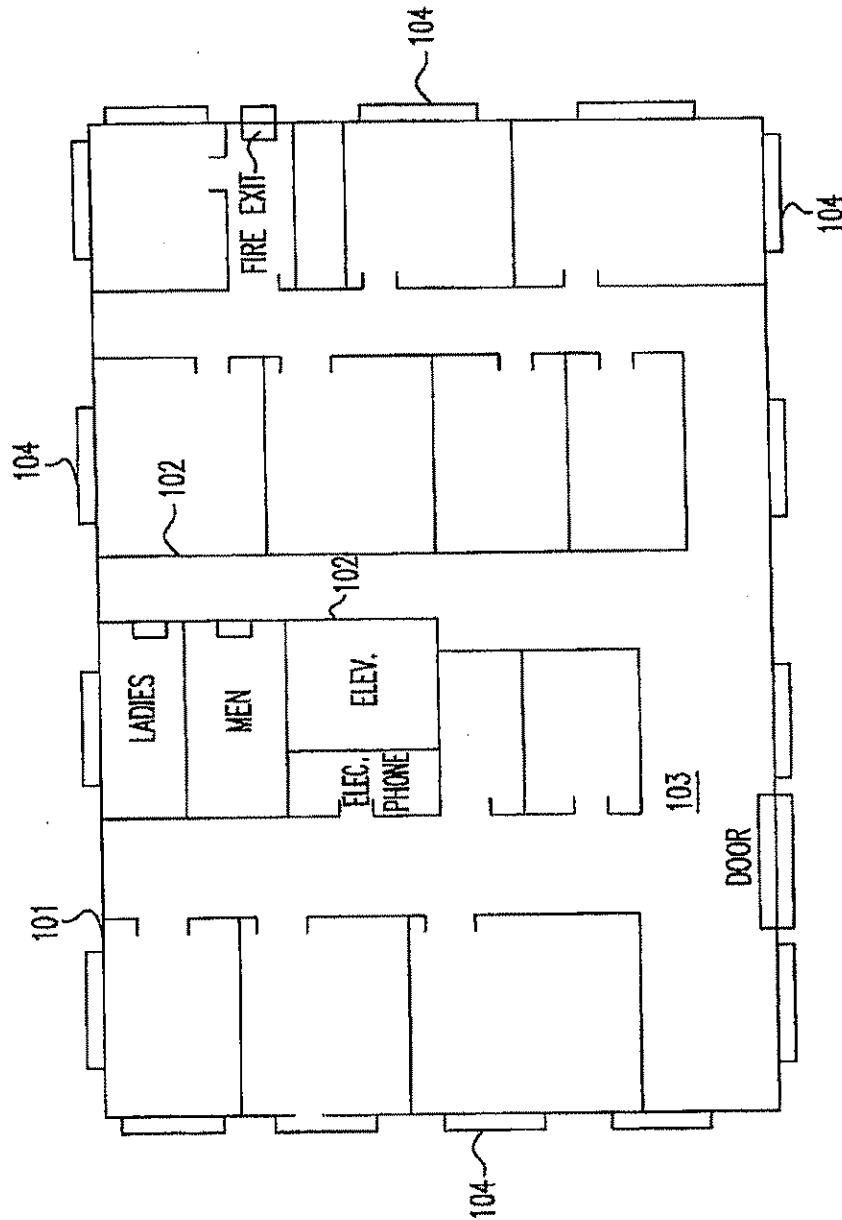


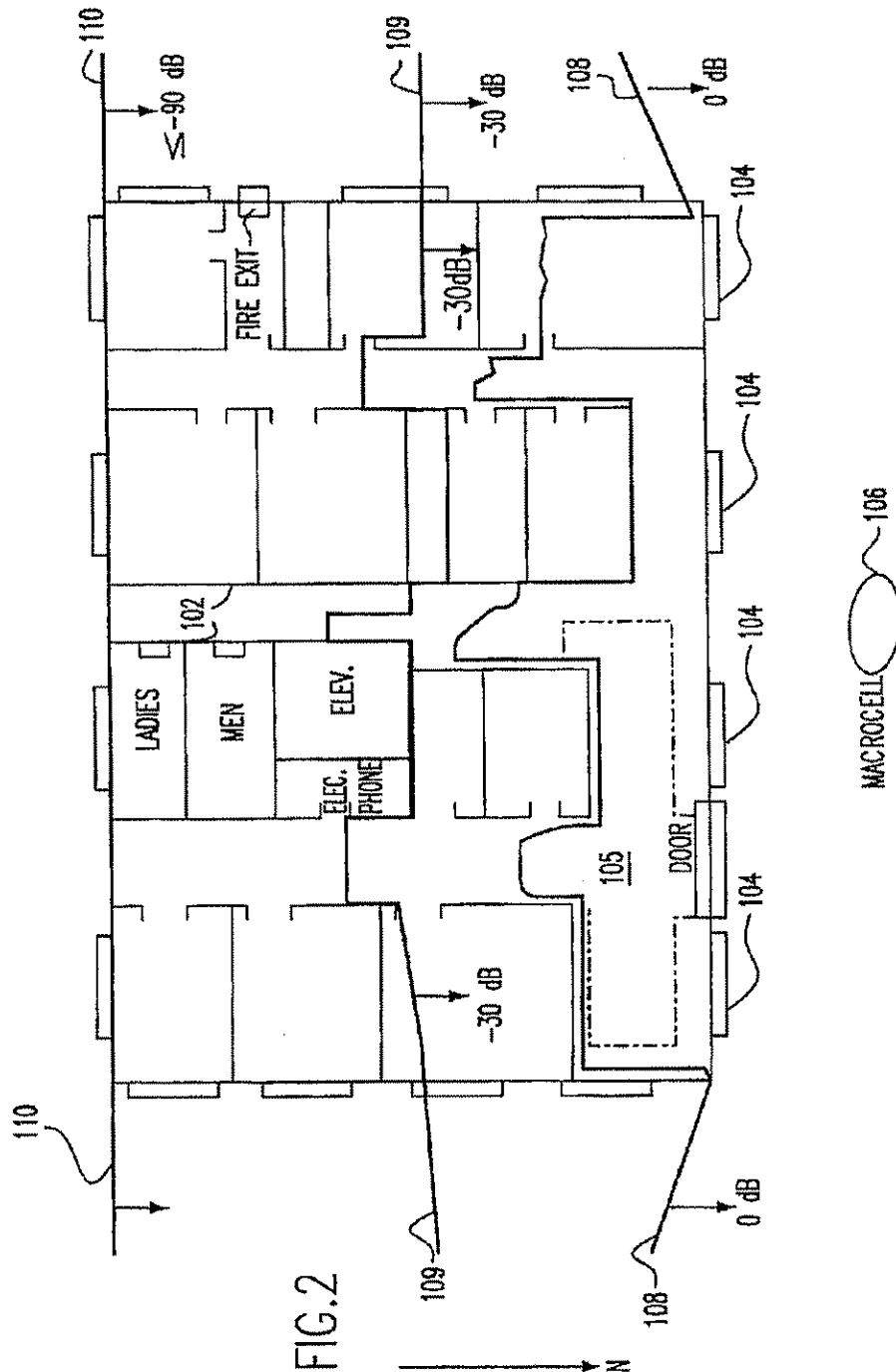
FIG. 1

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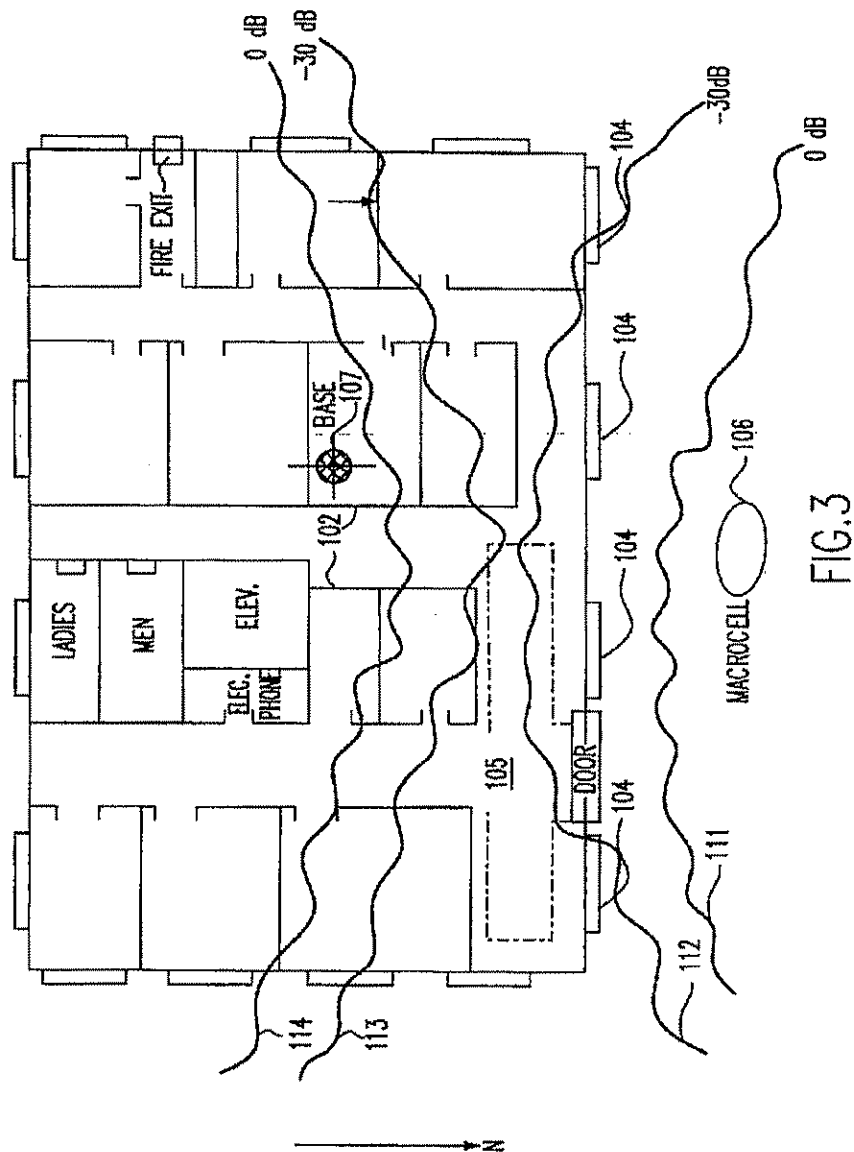


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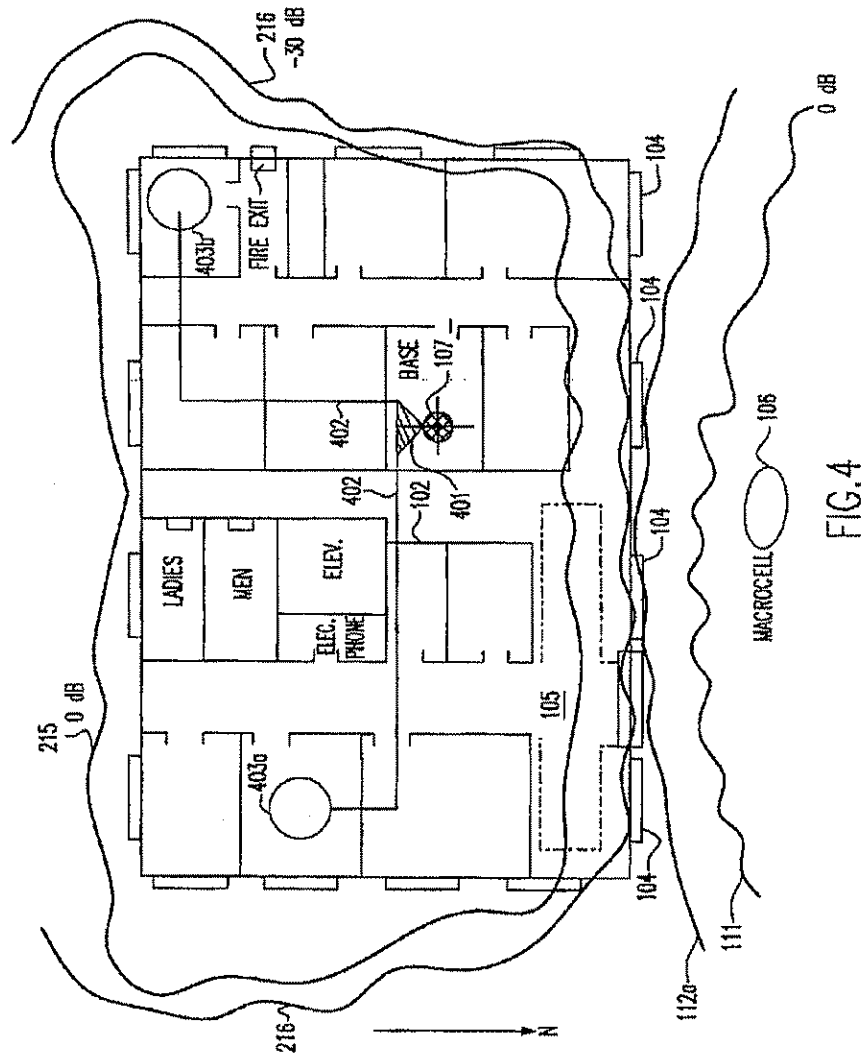


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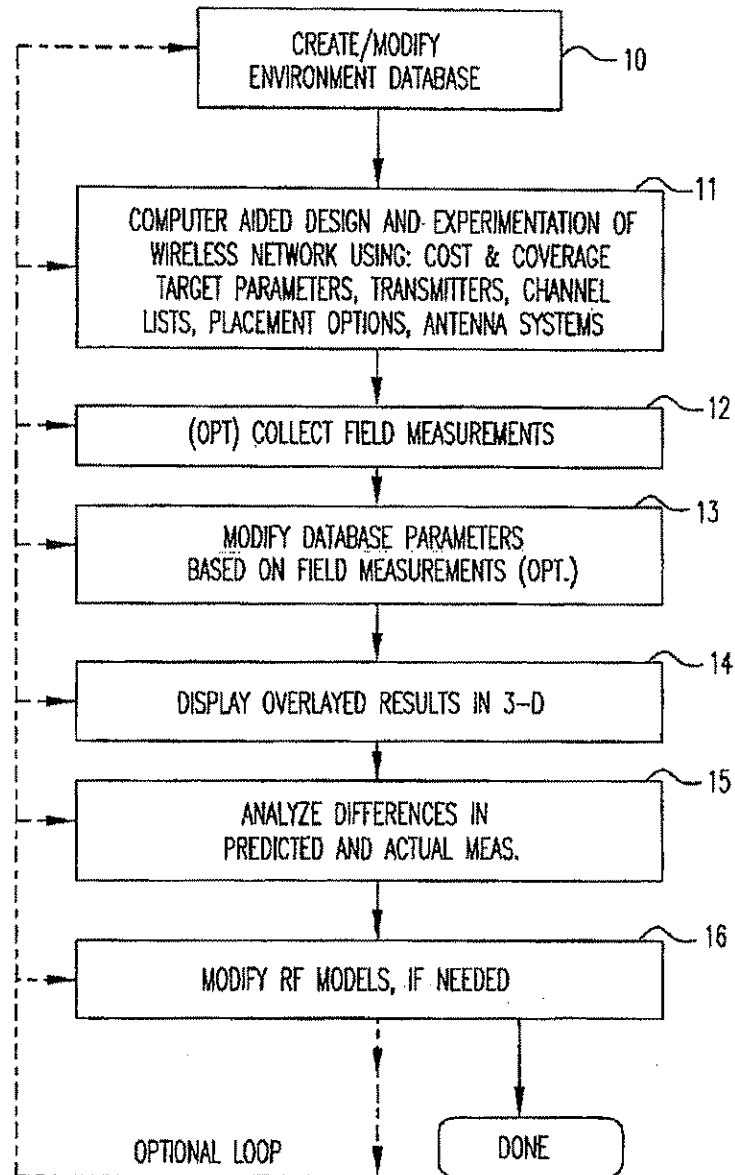


FIG.5



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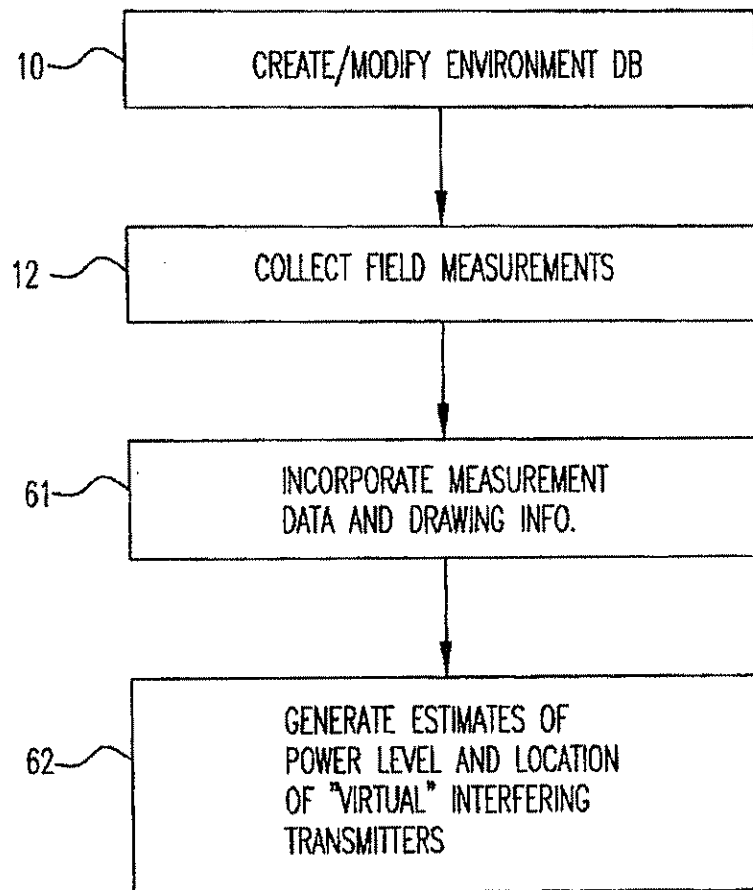


FIG.6

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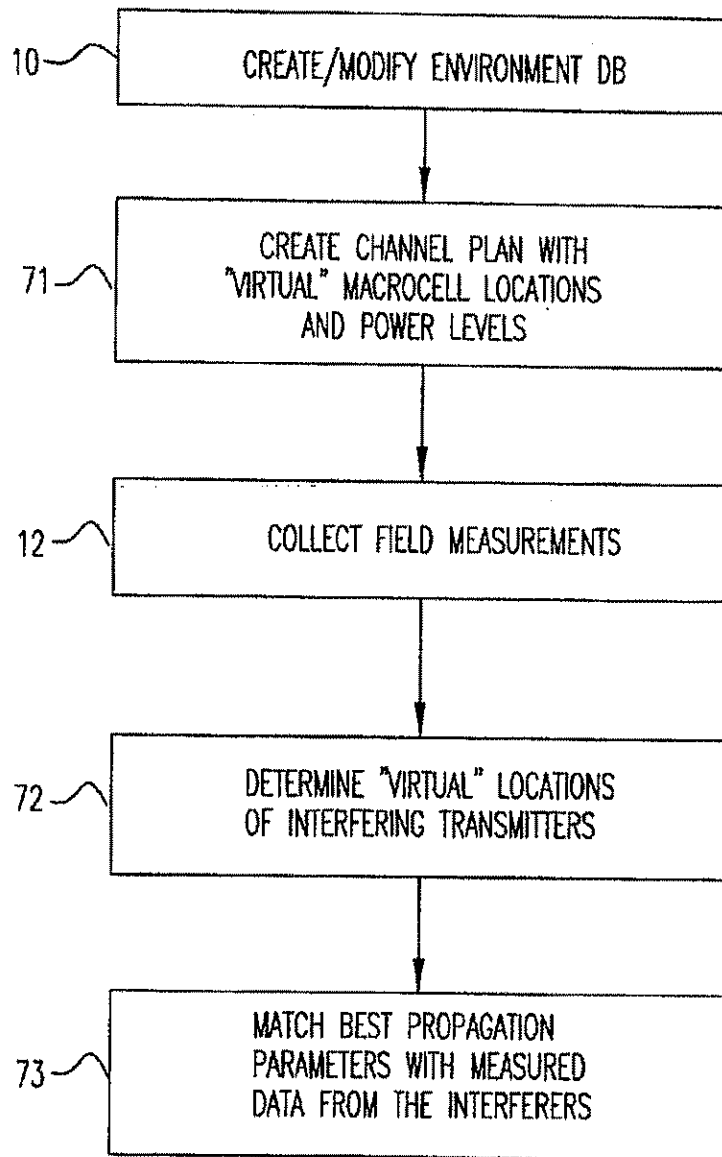


FIG. 7

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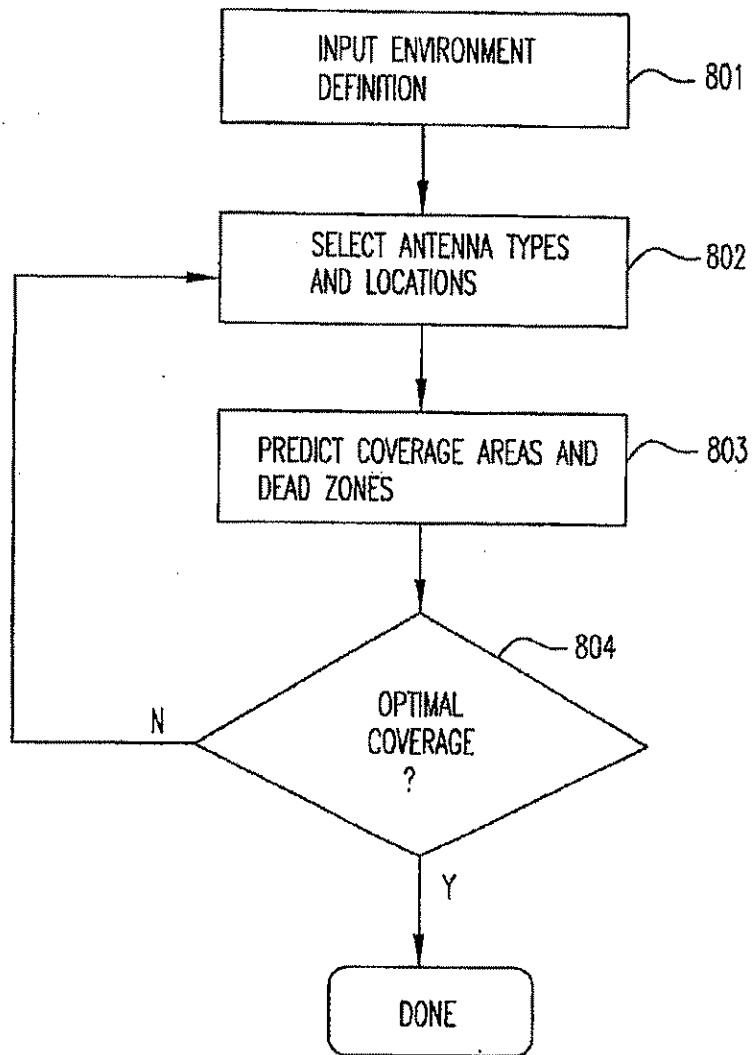


FIG. 8

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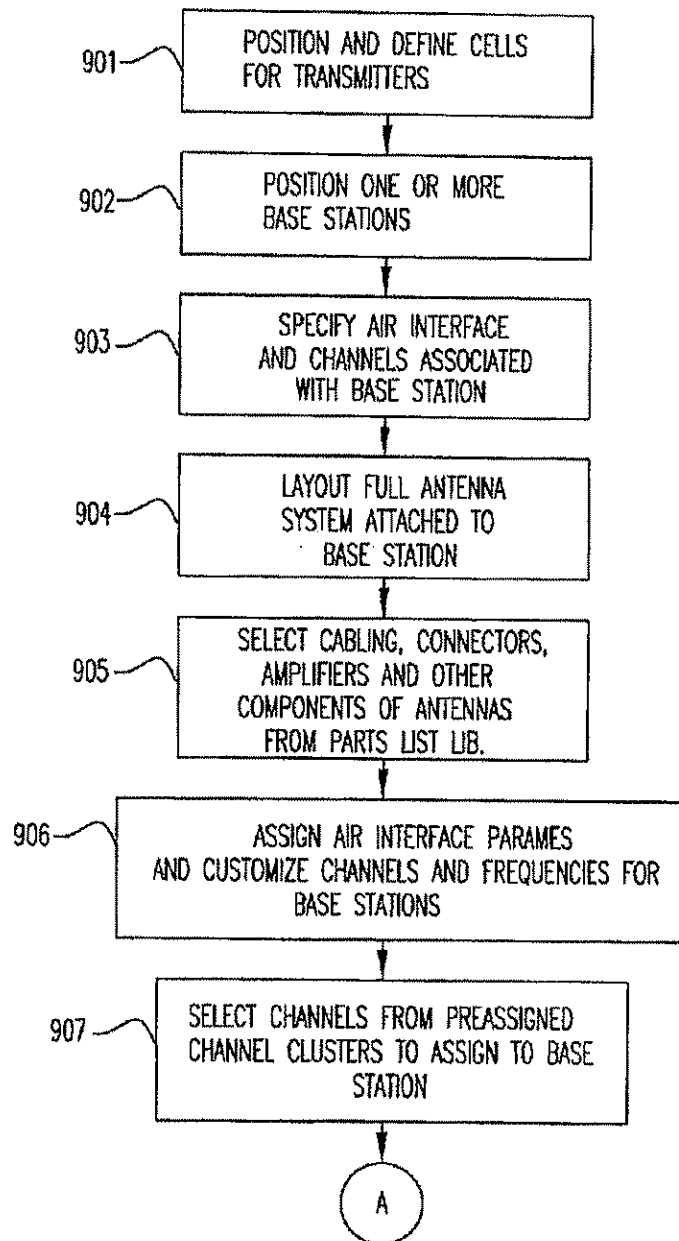


FIG.9A

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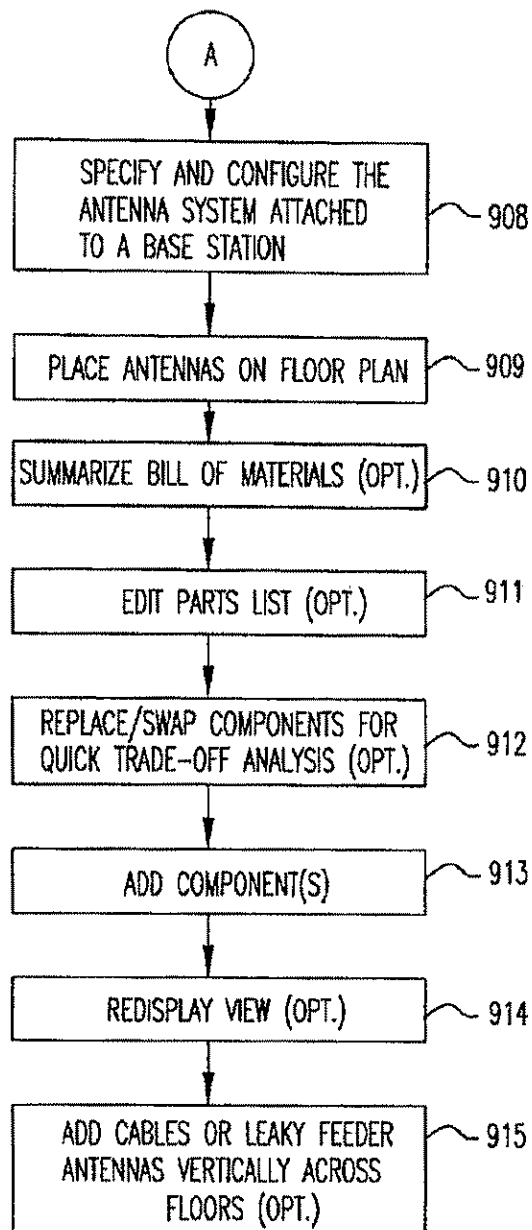


FIG.9B

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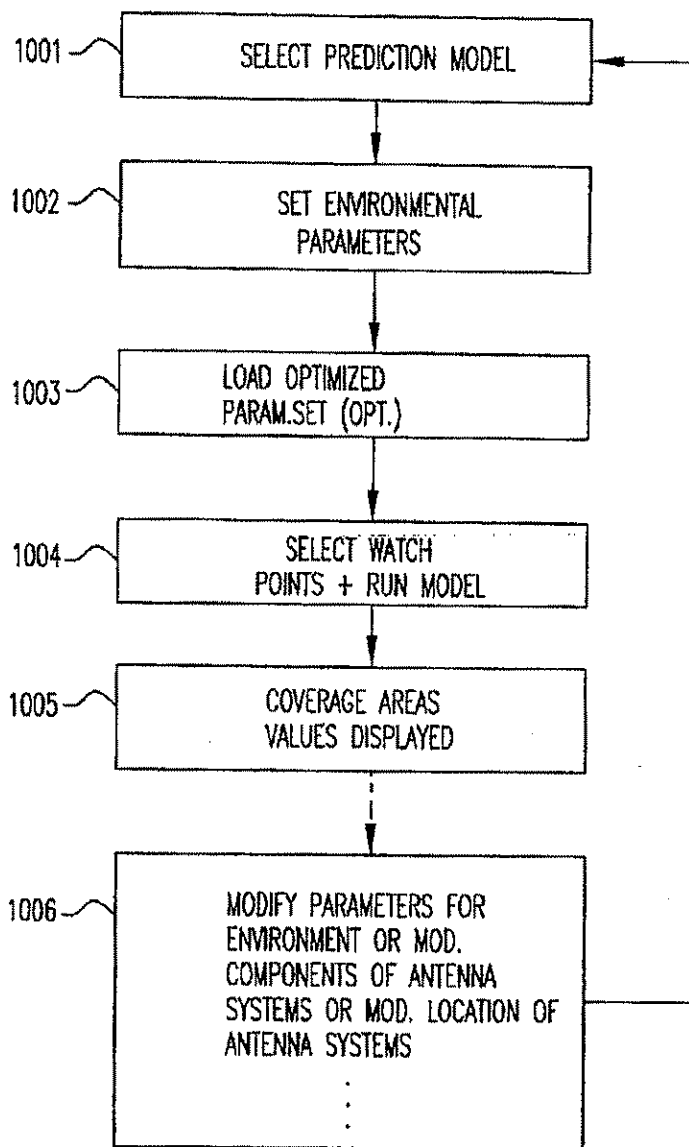


FIG.10

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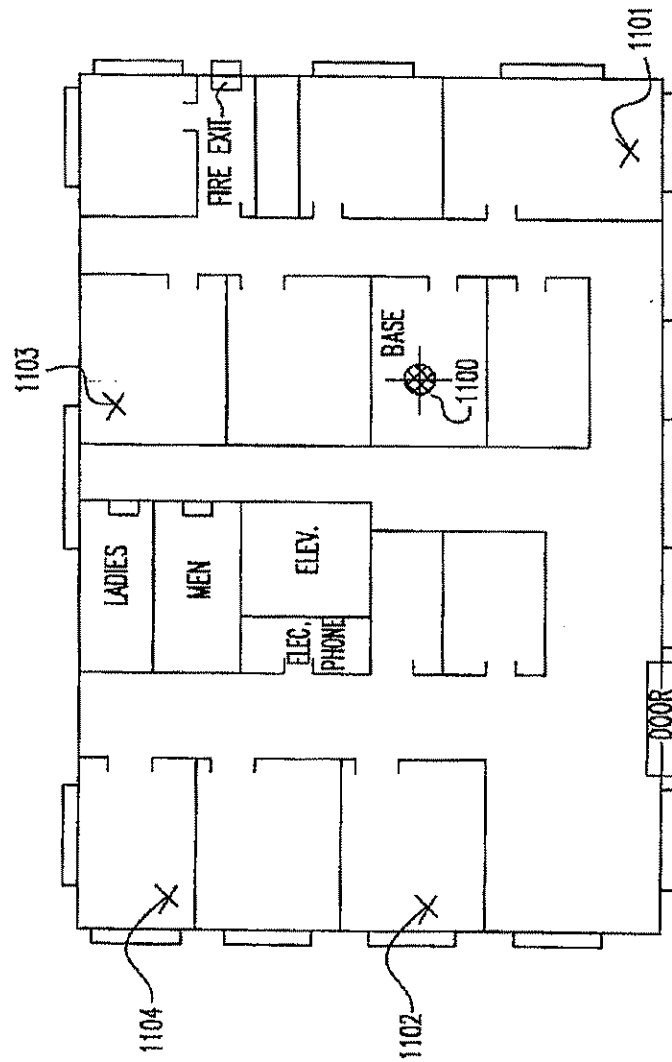


FIG. 11

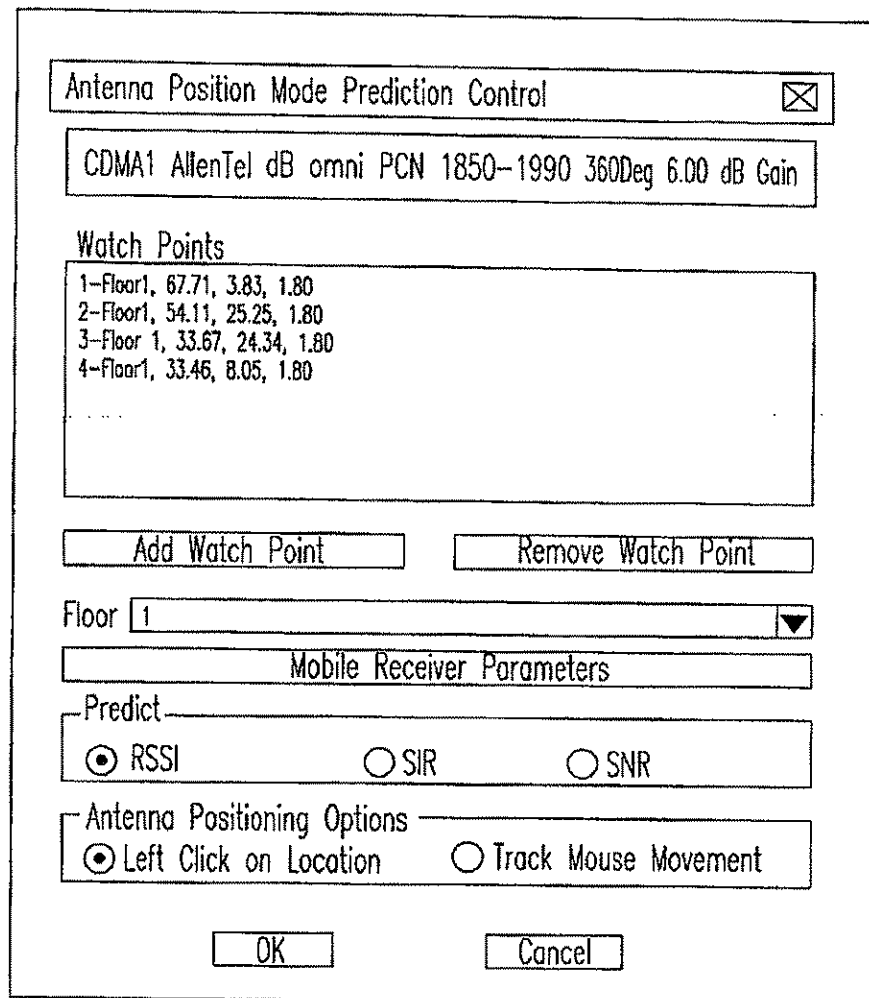


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Antenna Position Mode Prediction Control

CDMA1 AllenTel dB omni PCN 1850-1990 360Deg 6.00 dB Gain

Watch Points

- 1-Floor1, 67.71, 3.83, 1.80
- 2-Floor1, 54.11, 25.25, 1.80
- 3-Floor 1, 33.67, 24.34, 1.80
- 4-Floor1, 33.46, 8.05, 1.80

Add Watch Point Remove Watch Point

Floor 1

Mobile Receiver Parameters

Predict

☒ RSSI ☐ SIR ☐ SNR

Antenna Positioning Options

☒ Left Click on Location ☐ Track Mouse Movement

OK Cancel

FIG.12

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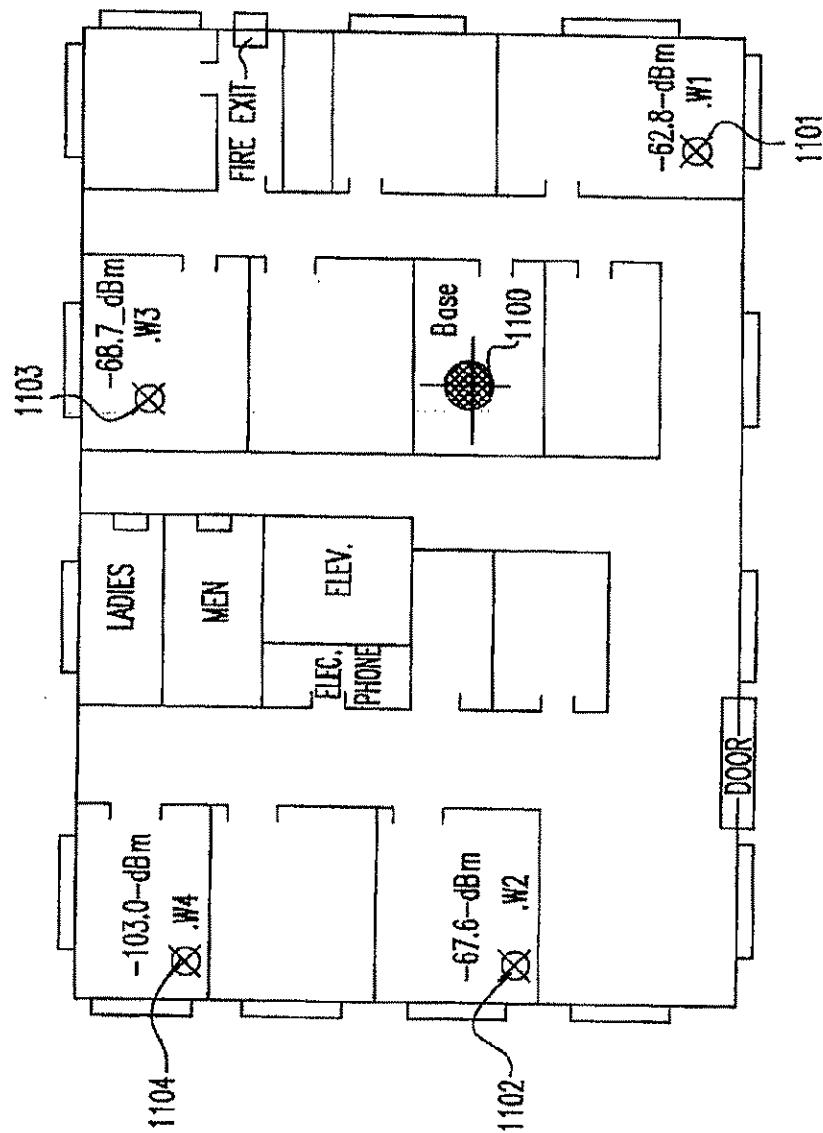


FIG. 13

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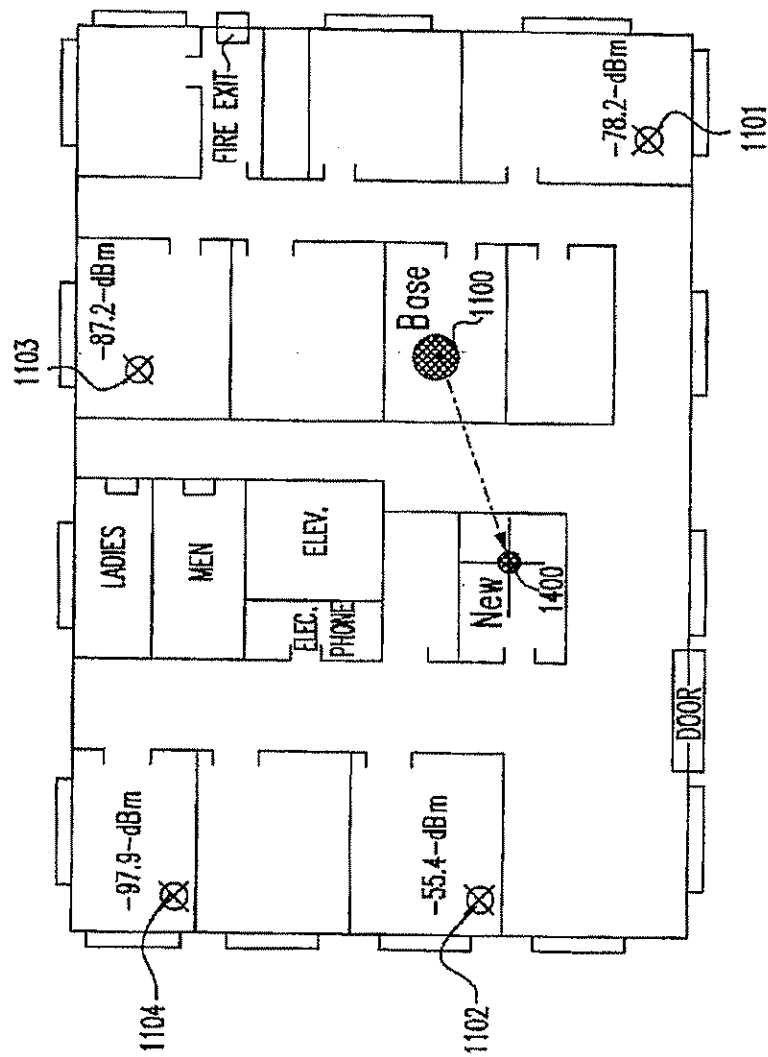


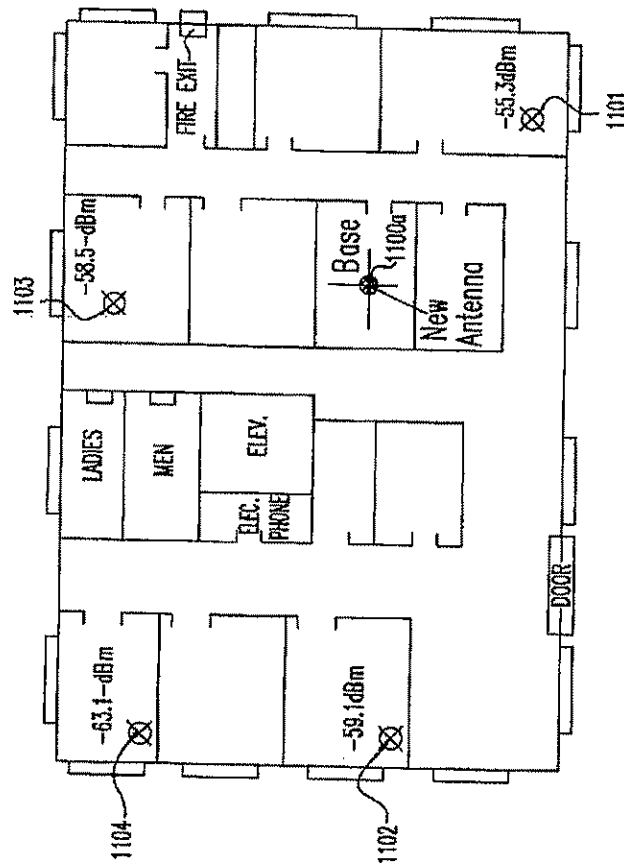
FIG.14

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Bill of Materials for Current Drawing

1610 {

SUBTOTAL (excluding base station CDMA1): \$0.00

BASE STATION: MACROCELL  
 DESCRIPTION: CDMA MACROCELL  
 FLOOR1  
 POSITION: 84.3, 44.0, 1.8  
 CHANNEL SET: MACROCELL: IS-95A CDMA Default  
 SUBCHANNEL SET: Default Channel Set  
 TXPOWER: 10.00 dBm  
 RF Bandwidth: 1.25 MHz  
 RECEIVER NOISE FIGURE: 0.00 dB  
 CHANNELS ASSIGNED TO BASE STATION

1611 {

1

--NAME: AllenTel PCN PANEL 1710-1990 92 Deg 9.00 dB Gain  
 TYPE: ANTENNA\_POINT  
 MANUFACTURER: Allen Telecom  
 PART NUMBER: DB972 1850  
 FREQUENCY: 1710-1990 MHz  
 PATTERN FILE: 972\_185.ant  
 FLOOR1  
 POSITION: 84.3, 44.0, 1.8  
 COST: \$0.00 ~ 1612

SUBTOTAL (excluding base station MACROCELL): \$0.00 ~ 1613  
 TOTAL COST(excluding base stations): \$0.00 ~ 1614

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FIG.16

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Bill of Materials for Current Drawing

1611 {

- TYPE: ANTENNA\_POINT
- MANUFACTURER: Allen Telecom
- PART NUMBER: DB972 1850
- FREQUENCY: 1710-1990 MHz
- PATTERN FILE: 972\_185.ant
- FLOOR1
- POSITION 84.3, 44.0, 1.8
- COST: \$250.00 ~ 1612a

1720 {

- NAME: 7/8", 50-ohm Foam Dielectric Coaxial Cable
- TYPE: CABLE
- MANUFACTURER: Andrew
- PART NUMBER: LDF5\*
- FREQUENCY: 2000MHz
- LENGTH: 120.41 m (395.06ft)
- LOSS PER 100 m: 6.46 dB
- TOTAL LOSS: 7.78 dB
- POSITION:
- Vertex0: 10.6, 0.8, 1.8
- Vertex1: 1.7, 2.8, 1.8
- Vertex2: 1.7, 31.0, 1.8
- Vertex3: 35.3, 31.0, 1.8
- Vertex4: 35.3, 23.5, 1.8
- Vertex5: 65.4, 23.6, 1.8
- Vertex6: 72.6, 32.0, 1.8
- COST: \$85.00 ~ 1721

SUBTOTAL(excluding base station MACROCELL): \$470.00 ~ 1613a

TOTAL COST(excluding base stations): \$470.00 ~ 1614a

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FIG.17

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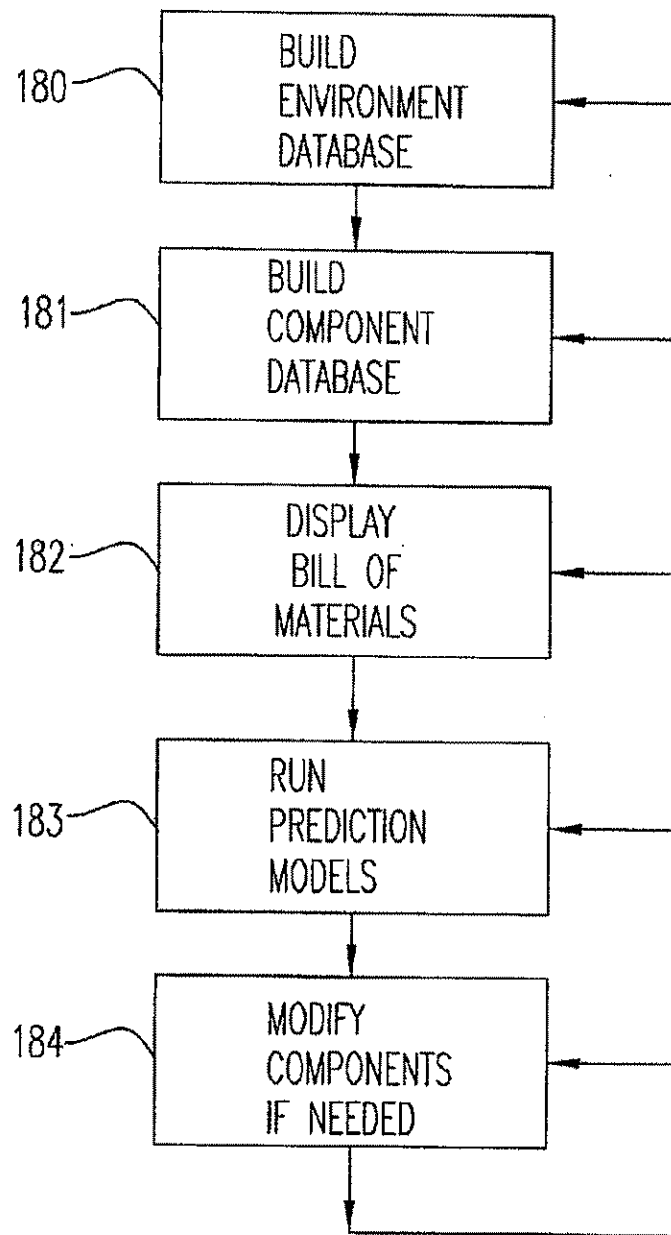


FIG.18



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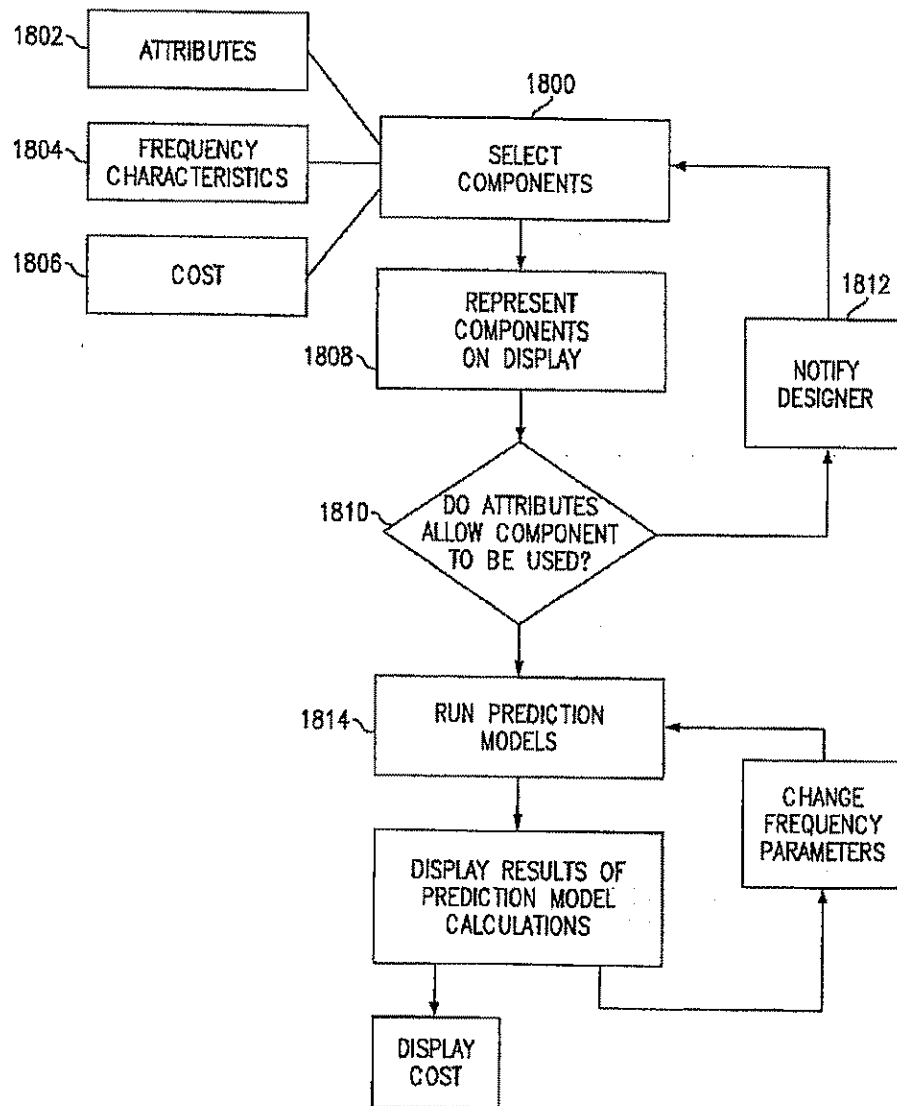


FIG. 19

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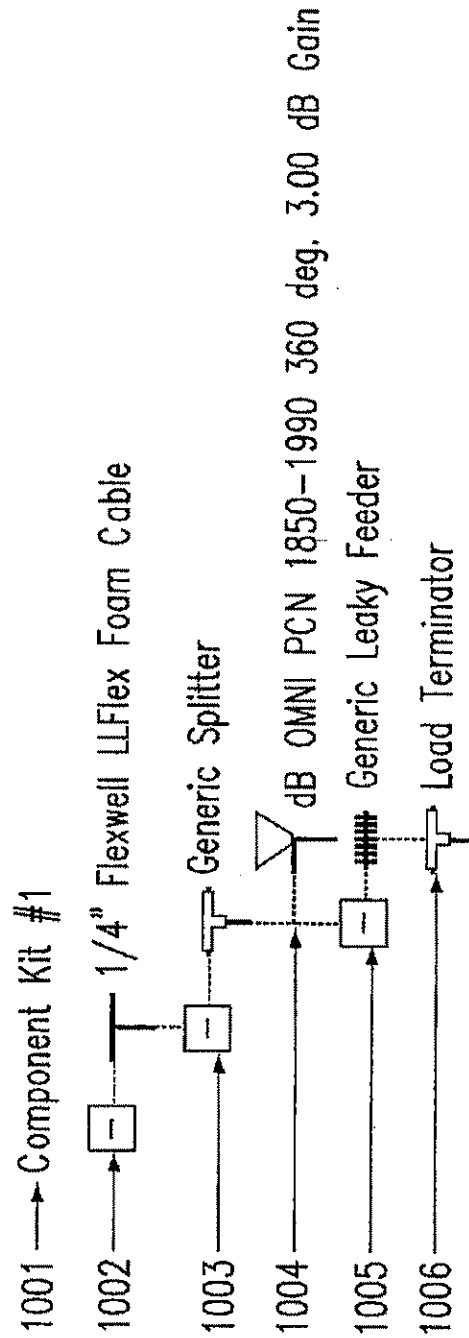


FIG. 20

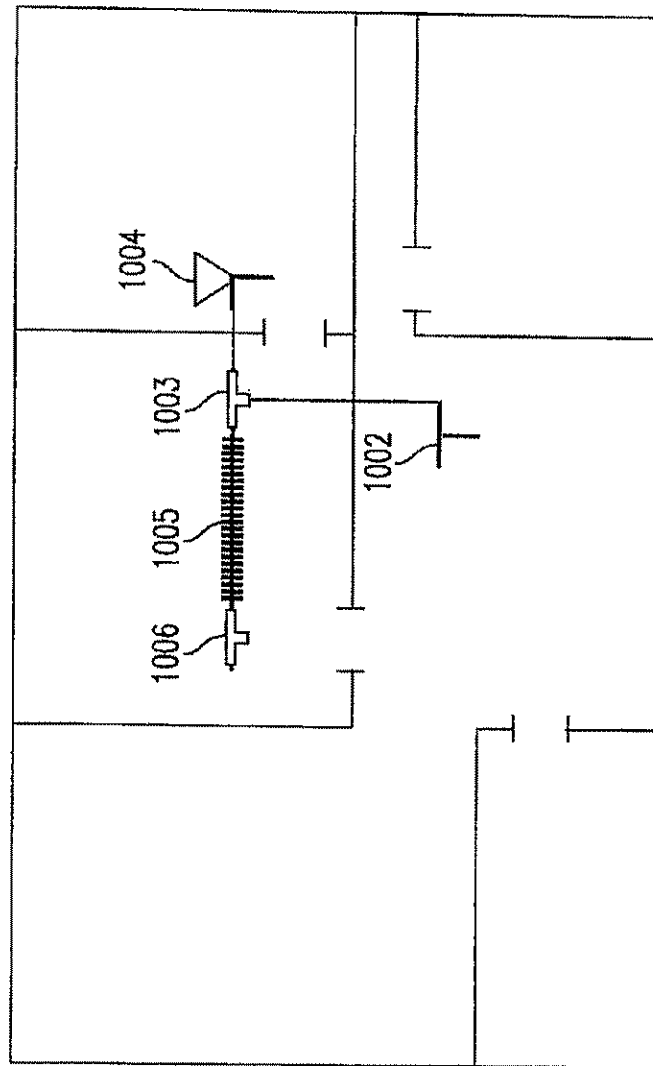


FIG. 21

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# METHOD AND SYSTEM FOR DESIGNING OR DEPLOYING A COMMUNICATIONS NETWORK WHICH CONSIDERS FREQUENCY DEPENDENT EFFECTS

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the U.S. patent application Ser. Nos. 09/352,678 filed Jul. 14, 1999, now U.S. Pat. No. 6,499,006; 09/318,840 filed May 26, 1999, now U.S. Pat. No. 6,317,599; 09/318,841 filed May 26, 1999; and 09/318,842 filed May 26, 1999, now U.S. Pat. No. 5,493,679; and is also related to the concurrently filed applications having U.S. Ser. Nos. 09/632,853, entitled "Method and System for Designing or Deploying a Communications Network which Considers Component Attributes"; and 09/633,133, entitled "Method and System for Designing or Deploying a Communications Network which Allows the Simultaneous Selection of Multiple Components", all of which are assigned to a common assignee, and the subject matter of these applications is incorporated herein by reference.

## DESCRIPTION

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention generally relates to engineering and management systems for the design of communications networks (both wireless and wired) and, more particularly, to a system and method for managing a real time bill of materials when designing, evaluating or optimizing the performance and/or costs of a communication system using a three-dimensional (3-D) representation of the environment. The present invention provides the design engineer with the ability to (1) group components together as a single connected or unconnected unit or "component kit" to simplify selection and assembly of hardware components, (2) have at his or her disposal in the Parts List Library performance parameters for selected components which are associated with the signal or "frequency" which will pass through the component such that electromechanical properties of the components can be considered on a frequency dependent basis automatically by the system, and (3) have at his or her disposal attributes which are associated with specific components in the Parts List Library which, acting in concert with real-time smart processing, provide the design engineer with notifications or warnings when he or she has proposed connections, components, or other arrangements which will not operate correctly in the communications network.

#### 2. Background Description

As wireless communications use increases, radio frequency (RF) coverage within buildings and signal penetration into buildings from outside transmitting sources has quickly become an important design issue for wireless engineers who must design and deploy cellular telephone systems, paging systems, or new wireless systems and technologies such as personal communication networks or wireless local area networks. Designers are frequently requested to determine if a radio transceiver location, or base station cell site can provide reliable service throughout an entire city, an office, building, arena or campus. A common problem for wireless systems is inadequate coverage, or a "dead zone," in a specific location, such as a conference room. It is now understood that an indoor wireless PBX (private branch exchange) system or wireless local area

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network (WLAN) can be rendered useless by interference from nearby, similar systems. The costs of in-building and microcell devices which provide wireless coverage within a 2 kilometer radius are diminishing, and the workload for RF engineers and technicians to install these on-premises systems is increasing sharply. Rapid engineering design and deployment methods for microcell and in-building wireless systems are vital for cost-efficient build-out.

Analyzing radio signal coverage penetration and interference is of critical importance for a number of reasons. A design engineer must determine if an existing outdoor large scale wireless system, or macrocell, will provide sufficient coverage throughout a building, or group of buildings (i.e., a campus). Alternatively, wireless engineers must determine whether local area coverage will be adequately supplemented by other existing macrocells, or whether indoor wireless transceivers, or picocells, must be added. The placement of these cells is critical from both a cost and performance standpoint. If an indoor wireless system is being planned that interferes with signals from an outdoor macrocell, the design engineer must predict how much interference can be expected and where it will manifest itself within the building, or group of buildings. Also, providing a wireless system that minimizes equipment infrastructure cost as well as installation cost is of significant economic importance. As in-building and microcell wireless systems proliferate, these issues must be resolved quickly, easily, and inexpensively, in a systematic and repeatable manner.

There are many computer aided design (CAD) products on the market that can be used to design the environment used in one's place of business or campus. WISE from Lucent Technology, Inc., SignalPro from EDX, PLANet by Mobile Systems International, Inc., and TEMS and TEMS Light from Ericsson are examples of wireless CAD products. In practice, however, a pre-existing building or campus is designed only on paper and a database of parameters defining the environment does not readily exist. It has been difficult, if not generally impossible, to gather this disparate information and manipulate the data for the purposes of planning and implementation of indoor and outdoor RF wireless communication systems, and each new environment requires tedious manual data formatting in order to run with computer generated wireless prediction models. Recent research efforts by AT&T Laboratories, Brooklyn Polytechnic, and Virginia Tech, are described in papers and technical reports entitled "Radio Propagation Measurements and Prediction Using Three-dimensional Ray Tracing in Urban Environments at 908 MHz and 1.9 GHz," (*IEEE Transactions on Vehicular Technology*, VOL. 48, No. 3, May 1999), by S. Kim, B. J. Guarino, Jr., T. M. Willis III, V. Ercog, S. J. Fortune, R. A. Valenzuela, L. W. Thomas, J. Ling, and J. D. Moore, (hereinafter "Radio Propagation"); "Achievable Accuracy of Site-Specific Path-Loss Predictions in Residential Environments," (*IEEE Transactions on Vehicular Technology*, VOL. 48, No. 3, May 1999), by L. Piazzzi and H. L. Bertoni; "Measurements and Models for Radio Path Loss and Penetration Loss In and Around Homes and Trees at 5.85 GHz," (*IEEE Transactions on Communications*, Vol. 46, No. 11, November 1998), by G. Durgin, T. S. Rappaport, and H. Xu; "Radio Propagation Prediction Techniques and Computer-Aided Channel Modeling for Embedded Wireless Microsystems," ARPA Annual Report, MPRG Technical Report MPRG-TR-94-12, July 1994, 14 pp., Virginia Tech, Blacksburg, by T. S. Rappaport, M. P. Koushik, J. C. Liberti, C. Pendyala, and T. P. Subramanian; "Radio Propagation Prediction Techniques and Computer-Aided Channel Modeling for Embedded Wireless

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While there are many methods available for designing wireless networks that provide adequate coverage, there is no easy method to ensure that the system will be cost effective. For instance, even though the coverage may be more than adequate, given the chosen wireless infrastructure components, the total cost of the system could be prohibitive.

#### SUMMARY OF THE INVENTION

It is an object of the invention to provide a rapid and automated method for generating a bill of materials and cost information in real time, as components for a desired wireless communication system are specified and/or replaced by substitute components, while continuously predicting wireless system performance. This automatic method for comparing the cost and performance of competing products or competing design methodologies, in real time, offers a significant value for wireless engineers and provides a marked improvement over present day techniques.

It is another object of this invention to provide a communications design engineer with a software tools which allow him or her to (1) group components together as a single unit or "component kit" to simplify selection and assembly of hardware components, (2) have at his or her disposal in the Parts List Library performance parameters for selected components which are associated with the signal or "frequency" which will pass through the component such that electromechanical properties of the components can be considered on a frequency dependent basis either automatically or through the use of a prompt (i.e., these being

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"frequency dependent characteristics"), and (3) have at his or her disposal attributes which are associated with specific components in the Parts List Library which, acting in concert with real-time smart processing, provide the design engineer with notifications or warnings when he or she has proposed connections, components, or other arrangements which will not operate correctly in the communications network.

According to the invention, a design engineer builds a model of the desired wireless communications system and specifies each component necessary to provide sufficient or optimal system performance. A parts list is maintained, in real time, that contains a definition of each system component and its associated performance and cost parameters. Using this method, the user is able to rapidly change the physical location of components within the wireless system in order to investigate alternative designs which may use different components, such as antennas and cables; or use different RF distribution methods and/or various types of coaxial or optical splitter systems, etc. Cost parameters include both component costs and installation costs. As the system is changed through a series of "what-if" scenarios, components are replaced with substitute components, cable lengths are modified, antenna systems and base stations are re-positioned to alternate locations, etc.

Each time a component is added to or deleted from the system model, the bill of materials is automatically updated and component costs, total costs, and altered system performance specifications are immediately available to the design engineer. The designer may choose to swap components for less expensive components. The performance characteristics of the system are automatically updated as cost choices are made to enable the designer to assess the changes in performance and cost at the same time.

The communications design engineer may group several components together into a collection referred to as a "component kit". Thereafter, he or she will need only select the "component kit" for inclusion in the computerized representation of the physical environment in which the communications network will be installed. These "component kits" could be custom designed by the design engineer or, alternatively, the software package included in this system could have preselected components bundled as a "component kit". The "component kits" allow the design engineer to more simply and quickly prepare models of the communications network since he or she will be able to select essentially bundles of communications components at a time. The system, however, will be able to track all the attributes of all the components in the selected component kits, including all performance attributes, pricing information, and other physical attributes and maintenance schedules, such that calculations will automatically consider the performance criteria, pricing and compatibility for the system designed by the engineer. The component kits may be assembled in the same manner as an actual communication system, including the associated cabling and distribution system, so that connections between components are already set up when the kit is added into a system; this saves a great deal of time for the engineer.

Various attributes of components will be associated with specific components in the Parts List Library, such as, for example, whether a component is an optical component or one which requires radio signals. As another example, the length of cable in which a signal can propagate without unacceptable deterioration may be associated with the cable in the parts list library. These attributes will be considered automatically by the system of this invention such that when



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a design engineer attempts to model connected components which are not properly connectable in the physical world, or when he or she attempts to use too long a cable length, etc., the system will provide a warning that the system being designed will be inoperative or be otherwise flawed. This will allow the designer to immediately recognize errors in design and correct for them during the design phase. Without such a facility, errors may not be discovered until installation or use of the system, at which point they are far more costly to repair.

Frequency dependent characteristics will also be associated with individual components in the Parts List Library. This will allow the design engineer to automatically consider the effects of signal frequency on the electrical performance of the designed communications network. This feature is especially valuable in light of the fact that most of said components are specifically designed to function in multiple frequency bands, with varying performance with respect to frequency.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

FIG. 1 shows an example of a simplified layout of a floor plan of a building;

FIG. 2 shows effective penetration of Radio Frequency (RF) transmission into a building from a macrocell;

FIG. 3 shows a simplified layout of a floor plan of a building including an outdoor macrocell and an indoor base station;

FIG. 4 shows the layout of FIG. 3, but with a revised base station designed to eliminate interference;

FIG. 5 is a flow diagram of a general method used to design a wireless communication network;

FIG. 6 is a flow diagram of a method used to generate estimates based on field measurements;

FIG. 7 is a flow diagram of a method used to match best propagation parameters with measured data;

FIG. 8 is a flow diagram of a method for prediction;

FIGS. 9A and 9B together make up a detailed flow diagram of a method to generate a design of a wireless network and determine its adequacy;

FIG. 10 is a flow diagram showing a method for using watch points during antenna repositioning or modification;

FIG. 11 shows a simplified layout of a floor plan of a building with a base station and watch points selected;

FIG. 12 shows a dialog box displaying the locations of the selected watch points and choices for display information;

FIG. 13 shows a simplified layout of a floor plan of a building with a base station and initial RSSI values for the selected watch points;

FIG. 14 shows a simplified layout of a floor plan of a building with a repositioned base station and changed RSSI values for the selected watch points;

FIG. 15 shows a simplified layout of a floor plan of a building with a re-engineered base station and changed RSSI values for the selected watch points;

FIG. 16 shows a bill of materials summary for a drawing, according to the preferred embodiment of the invention;

FIG. 17 shows a bill of materials summary for a drawing after costs have been added to a database, according to the preferred embodiment of the invention;

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FIG. 18 is a flow diagram showing the general method of the present invention;

FIG. 19 is a flow diagram showing the mechanisms for considering the effects of various attributes on and frequency characteristics on the communications system design, and, as required for notifying the designer of any inherent design flaws;

FIG. 20 is a computer display showing the assembly of a "component kit" according to the present invention; and

FIG. 21 is a schematic representation of a floor plan on which the components of a "component kit" have been displayed.

#### DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

##### Design of Wireless Communication Systems

Using the present method, it is now possible to assess the RF environment in a systematic, organized fashion by quickly viewing signal strength, or interference levels, or other wireless system performance measures. The current embodiment is designed specifically for use with the SitePlanner™ suite of products available from Wireless Valley Communications, Inc. of Blacksburg, Va. However, it will be apparent to one skilled in the art that the method could be practiced with other products either now known or to be developed in the future. (SitePlanner is a trademark of Wireless Valley Communications, Inc.)

Referring now to FIG. 1, there is shown a two-dimensional (2-D) simplified example of a layout of a building floor plan. The method uses 3-D computer aided design (CAD) renditions of a building, or a collection of buildings and/or surrounding terrain and foliage. However, for simplicity of illustration a 2-D figure is used. The various physical objects within the environment such as external walls 101 internal walls 102 and floors 103 are assigned appropriate physical, electrical, and aesthetic values. For example, outside walls 101 may be given a 10 dB attenuation loss, signals passing through interior walls 102 may be assigned 3 dB attenuation loss, and windows 104 may show a 2 dB RF penetration loss. In addition to attenuation, the obstructions 101, 102 and 103 are assigned other properties including reflectivity and surface roughness.

Estimated partition electrical properties loss values can be extracted from extensive propagation measurements already published, which are deduced from field experience, or the partition losses of a particular object can be measured directly and optimized instantly using the present invention combined with those methods described in the copending application Ser. No. 09/221,985, entitled "System for Creating a Computer Model and Measurement Database of a Wireless Communication Network" filed by T. S. Rappaport and R. R. Skidmore. Once the appropriate physical and electrical parameters are specified, any desired number of hardware components of RF sources can be placed in the 3-D building database, and received signal strengths (RSSI), network throughput, bit or frame or packet error rate, network delay, or carrier-to-interference (C/I), carrier-to-noise (C/N), or chip energy to interference (Ec/Io) ratios can be plotted directly onto the CAD drawing. The 3-D environment database could be built by a number of methods, the preferred method being disclosed in the concurrently filed, copending application Ser. No. 09/318,841. Traffic capacity analysis, frequency planning, co-channel interference analysis can be performed in the invention along with RF coverage. Other system performance metrics may be easily incorporated by one skilled in the art through well known equations.

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FIG. 2 depicts effective RF penetration into the building from the distant macrocell using a close-in virtual macrocell transmitting into the lossless distributed antenna.

Referring to FIG. 2, there are several windows 104, and even a large glass foyer 105, on the north wall of the building, so RF penetration into this part of the building is quite good, as shown by contour lines 108 and 109 for 0 dB and -30 dB, respectively. Even so, interior walls 102 cause signal levels in some areas to drop below a minimum useable signal strength of about -90 dBm, especially in some of the southern rooms, as shown by contour line 110. Consequently, macrocell coverage there will probably be poor.

Other outdoor macrocells can be modeled in the same way, and their signal strength contours plotted, to determine if hand-offs can compensate for the inadequacies of the macrocell north of the building. If not, then indoor picocells (and their distributed feed systems, antennas, and antenna patterns) can be easily added if necessary, and their performance checked using the method, to complement coverage provided by the macrocells.

The mathematical propagation models used to predict and optimize antenna positioning in a desired environment may include a number of predictive techniques models, such as those described in the previously cited and following technical reports and papers: "Interactive Coverage Region and System Design Simulation for Wireless Communication Systems in Multi-Floored Indoor Environments, SMT Plus," *IEEE ICUPC '96 Proceedings*, by R. R. Skidmore, T. S. Rappaport, and L. Abbott which is hereby incorporated by reference. Some simple models are also briefly described in "SiteManner 3.16 for Windows 95/98/NT User's Manual" (Wireless Valley Communications, Inc. 1999), hereby incorporated by reference. It would be apparent to one skilled in the art how to apply other system performance models to this method.

Interference, instead of radio signal strength, is the dominant performance-limiting factor in many situations due to increased wireless communications use. Modeling interference from any source to an established or contemplated wireless system is straightforward using the method. Suppose, for example, that an indoor wireless communication system is assigned a frequency set identical to that of an outdoor wireless system. Although the indoor system may provide sufficient RSSI throughout its coverage area, interference from the outside system may still render the indoor wireless system ineffectual in certain parts of the building.

Caution must be used, however, when modeling and analyzing interference, since the detrimental effect may also depend upon technologies and/or signal processing technologies, not just signal power levels. For example, a geographic area could have similar narrowband and/or wideband in the 800 MHz cellular bands, for instance with Advanced Mobile Phone System (AMPS) and Code Division Multiple Access (CDMA) systems, but users using either technology may be able to coexist if their respective demodulation processes reject interference provided by the undesired system. The current embodiment of this invention allows the user to select the air interface/technology being used by the wireless system being designed and automatically adjust the prediction of interference accordingly.

FIG. 3 shows another rendition of the office building example, but an indoor wireless system 107 has been added. In this example, 800 MHz AMPS technology is assigned to both transmitters 106 and 107. Differing wireless standards and technologies such as CDMA and Global System Mobile

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(GSM) could have been selected as well. The present invention uses a database to represent the exact physical air interface standards of a wide range of technologies and may be easily edited for future interface standards. As new technologies are developed, one skilled in the art could easily modify this invention to include the new technologies.

The outdoor wireless system 106 is now interfering with the indoor network, and the effect is checked by plotting C/I contours 111 and 112 at 0 dB and -30 dB, respectively, for the outdoor system and also plotting C/I contours 113 and 114 at 0 dB and -30 dB for the indoor system. The 0 dB contour 114 shows where the desired and interfering signal levels are equal, so the interfering outdoor system's signal predominates in areas outside this contour. It is obvious that the indoor network is rendered useless throughout many parts of the building. There are a number of possible solutions that may be analyzed by a designer using the present invention.

One solution is to change the indoor system's antenna location or increase the transmitted power, add more nodes, or select a different frequency set. These changes may be made with the simple click of a mouse in the method of the invention, so that new channel sets, antenna locations, or alternative antenna systems (such as in-building distributed systems, directional antennas, or leaky feeders) may be evaluated quickly, thereby eliminating guesswork and/or costly on-site experimentation with actual hardware. Instead of displaying contours of coverage or interference, the present invention also allows the user to specify fixed or moveable watch points that indicate or display predicted performance in extremely rapid fashion at specific points in the environment.

For example, FIG. 4 illustrates how the same indoor wireless system of FIG. 3 can provide adequate C/I protection when connected to a distributed indoor antenna system consisting of a two-way splitter 401 (3 dB loss+insertion loss) and two 40 foot cable runs 402 to popular commercial indoor omnidirectional antennas 403. A look at the new 0 dB contour lines 111 and 215, and -30 dB contour lines 112a and 216 show that the coverage inside the building is now adequate; the outdoor system 106 no longer causes significant interference in most parts of the building. Watch points allow a user to instantly determine spot coverage or other system performance without having to wait for the computation and display of contour plots.

The method allows any type of distributed antenna system to be modeled within seconds, while continuously monitoring and analyzing the component and installation cost and resulting link budget, as disclosed below, enabling "what-if" designs to be carried out on the fly with minimum guess work and wasted time. It is clear that while an RF system is shown and described herein, the same concepts may be applied to any communications network, with a wide range of distribution methods and components.

In the present embodiment of the invention, the designer identifies locations in the 3-D environmental database where certain levels of wireless system performance are desirable or critical. These locations, termed "watch points", are points in three-dimensional space which the designer identifies by visually pointing and/or clicking with a mouse or other input device at the desired location in the 3-D environmental database. Any number of such watch points may be placed throughout the 3-D environment at any location. Watch points may be designated prior to performing a performance prediction on a given wireless communication system, or may be dynamically created by the user at any

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time during the course of a wireless system performance calculation using the same point and click technique described above.

Watch points provide graphical and/or textual feedback to a designer regarding the wireless system performance throughout the environment. Depending on the type of visual feedback desired by the designer, watch points may take the form of one or more of the following:

A computed number displayed as text that represents received signal strength (RSSI), signal-to-interference ratio (SIR), signal-to-noise ratio (SNR), frame error rate (FER), bit error rate (BER), or other wireless system performance metrics;

A small region of solid color whose shade and/or tint varies relative to some computed wireless system performance metric;

Colored lines linking the watch point location with the location one or more antennas in the wireless communication system, where the color, thickness, and/or other physical aspect of the connecting line varies relative to some computed wireless system performance metric and dependent upon whether the forward or reverse wireless system channel is being analyzed;

Other forms designated by the designer; or

Any combination of the above...

In all cases, the graphical and/or textual representation of each watch point is updated in real-time as a result of the instantaneous computation of the wireless system performance metrics, which are linked to the 3-D environmental database, and initiated due to dynamic changes being made to the wireless system configuration and/or watch point position itself by the user. For example, if the user repositions an antenna using the mouse or other input device, the effect of doing so on the overall wireless system performance is computed and the results are displayed via changes in the appearance of watch points. In addition, numerical values predicted at the watch points are displayed in summary in a dialog window and written to a text file for later analysis. This process is described in greater detail in the following sections.

The preferred embodiment of the invention utilizes a 3-D environmental database containing information relevant to the prediction of wireless communication system performance. This information includes but is not limited to the location, and the physical and electromagnetic properties of obstructions within the 3-D environment, where an obstruction could be any physical object or landscape feature within the environment (e.g., walls, doors, windows, buildings, trees, terrain features, etc.), as well as the position and physical and electrical properties of communications hardware to be used or simulated in the environment.

The designer identifies the location and type of all wireless communication system equipment within the 3-D environmental database. This point-and-click process involves the designer selecting the desired component from a computer parts database and then visually positioning, orienting, and interconnecting various hardware components within the 3-D environmental database to form complete wireless communication systems. The preferred embodiment of the computer parts database is more fully described below. The resulting interconnected network of RF hardware components (commonly known as a wireless distributed antenna) is preferably assembled using either a drag and drop technique or a pick and place and is graphically displayed overlaid upon the 3-D environmental database, and utilizes electromechanical information available for each compo-

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nent via the parts list library in order to fully describe the physical operating characteristics of the wireless communication system (e.g., the system noise figure, antenna radiation characteristics, frequencies, etc.). This information is directly utilized during the prediction of wireless system performance metrics and is discussed later.

The present invention represents a dramatic improvement over prior art by providing the design engineer with instant feedback on wireless system performance metrics as the user alters the physical location of switches, routers, repeaters, transducers, couplers, transmitters, receivers, and other components described elsewhere or which would be known by those of skill in the art, or otherwise modifies the antenna system. The current embodiment utilizes the concept of watch points to implement this. Multiple methods of display and a wide range of settings are available for the designer to use in optimizing antenna placement based upon wireless system performance values displayed at each watch point. One skilled in the art could see how watch points as they are herein described could apply to different implementations as well. Descriptions of the different techniques implemented in the current invention are provided in the following sections.

One form of the method allows the designer to dynamically alter the position, orientation, and/or type of any hardware component utilized within a wireless communication system modeled in a 3-D environmental database. Using this technique, the designer may identify watch points representing critical areas of the 3-D environment that require a certain level of wireless system performance. Such areas could include the office of the Chief Executive Officer (CEO) of a company, a conference room, a city park, or the office of a surgeon on call. Next the designer selects the component of interest within the wireless system. In the present invention, this would be the selection of an antenna or leaky feeder antenna, for example, but one skilled in the art could see that this could be any physical antenna system component. Once the desired hardware component is selected, the designer may begin making changes to the state of the component. For example, by moving the mouse or other input device cursor, the user could effectively relocate the selected component to another position in the 3-D environmental database. This involves the user visually moving the mouse cursor, in real-time, such that the cursor resides in another portions of the 3-D database. The present invention recalculates wireless system performance based upon RSSI, SIR, SNR, FER, BER, or other metric, incorporating the user's desired change in the position of the selected component.

The calculations combine the electromechanical properties of each component in the wireless communication system (e.g., noise figure, attenuation loss or amplification, antenna radiation pattern, etc.), the electromagnetic properties of the 3-D environmental database, and radio wave propagation techniques (detailed later) to provide an estimate of the wireless system performance. Calculations are performed at each watch point the user has identified, and the graphical display of the watch point is updated to reflect the result of the calculations.

As the user moves the mouse cursor and effectively repositions the selected component, the overall performance of the wireless communication system may be altered. For example, if the selected component is an antenna, repositioning the antenna changes the origination point of radio wave signals being broadcast from the antenna, and can thus dramatically change the reception of adequate RF signal throughout the environment. Because the graphical display



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of the watch points is updated in real-time as the selected component is repositioned, the designer is provided instant feedback on the revised wireless system performance, and can make design decisions based upon the viability of multiple proposed locations and/or wireless system configurations rapidly. While many of the concepts discussed above deal with wireless networks, one of ordinary skill in the art would understand that similar features may be implemented for optical, infrared, or baseband networks that use fixed or portable terminals.

In addition to the functionality described above, the designer is free to add additional watch points in any location within the 3-D environmental database at any time during a communication system performance prediction. In the current implementation, the designer clicks with the mouse or other input device on the desired location in the 3-D environmental database to create a new watch point at the selected location that is then updated throughout the remainder of the performance prediction.

In a similar fashion, the preferred embodiment enables a designer to reorient a selected antenna in real-time with respect to any coordinate axis while the graphical display of all drawing watch points is updated to reflect the revised wireless system performance metrics as a result of the new antenna orientation.

In a similar fashion, a designer may replace an existing hardware component in the wireless communication system with any component available from the parts list library. In doing so, the changes to the wireless communication system performance as a result of the replacement is reflected in the graphical display of the watch points.

In a similar fashion, a designer may selectively include or exclude any subset of components within the wireless communication system while selecting components to involve in the wireless system performance calculation. For example, a designer could consider the effect of repositioning a single antenna, or could consider the combined, composite effect on the watch points as individual antennas are repositioned within a wireless system network consisting of additional, fixed antenna placements.

In a similar fashion, the designer may choose to allow watch points to be mobile. That is, instead of positioning a watch point and having the graphical display of the watch point reflect the changing wireless system performance metric, the designer could instead identify a watch point whose position is mobile but whose graphical display remains constant. In this scenario, the position of the watch point fluctuates along a linear path traced between itself and the current location of the mouse cursor until a position within the 3-D database is found at which the desired level of wireless system performance metric is maintained. For example, the designer may create a watch point to maintain a constant graphical display synonymous with -65 dBm RSSI. As the user repositions, reorients, or otherwise alters components within the wireless communication system, the watch point alters its position within the 3-D environmental database until a position is found at which a calculated value of -65 dBm RSSI is determined.

In addition to enabling a designer to reposition, reorient, and/or replace wireless system components in real-time while visualizing the impact of such changes at selected watch points within the 3-D database, the user may choose to maintain the current configuration of the wireless communication system and instead create a single, mobile watch point. The watch point thus created is dynamically repositioned within the 3-D environmental database in real-time by the user by simply repositioning the mouse cursor.

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Positioning the mouse cursor at a given location within the 3-D environmental database is equivalent to repositioning the watch point to match that location. In the present invention, this technique is used to allow the mobile watch point to represent a mobile user in the 3-D environmental database. As in the previous scenarios, the graphical display of the watch point is updated in real-time to reflect predicted wireless system performance metrics at the watch point position. The designer is free to select individual subsets of wireless system components to involve in the calculations of wireless system performance. Thus the graphical display of the watch point may reflect the performance metrics specific to individual wireless system components or the composite performance metrics due to the combined effect of multiple selected components. For example, the radiating power of multiple antennas can be combined into a single measure of received signal strength.

The two primary uses of the single mobile watch point technique involve the analysis of the forward link (or down link) and reverse link (or up link) of the wireless system. The forward link of a wireless communication system involves the flow of radio signals from the fixed wireless system to the mobile user, while the reverse link of a wireless communication system involves the flow of radio signals from the mobile user to the fixed wireless system. In the present embodiment, line segments are drawn between the mobile watch point (which is also the mouse cursor) to each antenna the designer has included in the wireless system performance prediction. In addition, the individual or subsets of antennas identified as having the best wireless system performance characteristics are differentiated from the other antennas by altering the color and/or other physical appearance of the connector lines between the antennas and the watch point. As the designer then repositions the mouse cursor, the selected location for the watch point in the 3-D database, and therefore the effective location of the mobile user, is adjusted to match that of the mouse cursor. The wireless system performance metrics are recalculated at the watch point location for the antenna components selected by the designer, and the graphical display of the watch point and all connector lines is updated accordingly.

Another improvement over the prior art is the ability to dynamically model the repositioning of leaky feeder antennas and visualize the effects on wireless system performance. A leaky feeder antenna can be thought of as a cable with many holes regularly spaced along its length. Such a cable would experience a signal loss or emanation at every hole and would thus radiate RF energy along the entire cable length. Leaky feeder antenna, or lossy coaxial cable as it is sometimes referred, can be thought of as analogous to a soaker hose where water flows in at the head of the hose and leaks out through a series of holes. The present method allows the designer to dynamically re-position a portion of the leaky feeder antenna and see in real time the effects on wireless system performance at the specified watch points. In the preferred embodiment, distributed antenna systems can be analyzed in terms of the contributions of individual antennas or collections of antennas taken as a whole, providing "composite" results in the latter case.

Referring to FIG. 5, there is shown the general method of the invention. Before one can run an automated predictive model on a desired environment, a 3-D electronic representation of that environment must be created in function block 10. The preferred method for generating a 3-D building or environment database is disclosed in the concurrently filed, copending application Ser. No. 09/318,841. The resulting definition utilizes a specially formatted vector database

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format and comprises lines and polygons rather than individual pixels (as in a raster format). The arrangement of lines and polygons in the database corresponds to obstructions/partitions in the environment. For example, a line in a database could represent a wall, a door, tree, a building wall, or some other obstruction/partition in the modeled environment.

From the standpoint of radio wave propagation, each of the obstruction/partition in an environment has several electromagnetic properties. When a radio wave signal intersects a physical surface, several things occur. A certain percentage of the radio wave reflects off of the surface and continues along an altered trajectory. A certain percentage of the radio wave penetrates through or is absorbed by the surface and continues along its course. A certain percentage of the radio wave is scattered upon striking the surface. The electromagnetic properties given to the obstruction/partitions define this interaction. Each obstruction/partitions has parameters that include an attenuation factor, surface roughness, and reflectivity. The attenuation factor determines the amount of power a radio signal loses upon striking a given obstruction. The reflectivity determines the amount of the radio signal that is reflected from the obstruction. The surface roughness provides information used to determine how much of the radio signal is scattered and/or dissipated upon striking an obstruction of the given type.

Once this 3-D database of obstruction data has been built, the design engineer performs computer aided design and experimentation of a wireless network to be deployed in the modeled environment in function block 11, to be described later. Cost and wireless system performance target parameters, transmitters, channel lists, placement options and antenna systems are all taken into account by the present invention.

In order to fine tune the experimental predictions, RF measurements may be optionally taken in function block 12. A preferred method for collecting RF measurements is disclosed in copending application Ser. No. 09/221,985, supra. If necessary, database parameters that define the partition/obstruction characteristics may be modified using RF measurements as a guide to more accurately represent the modeled 3-D environment in function block 13.

The results of the predictive models may be displayed in 3-D overlaid with the RF measurement data, if any, at any time in function block 14. The design engineer analyzes the differences in the predicted and actual measurements in function block 15, and then modifies the RF predictive models, if needed, in function block 16. If necessary, the 3-D environment database may be modified based on the actual measurements to more accurately represent the wireless system coverage areas in function block 10, and so on iteratively until done. The designer can optionally continue with any other step in this process, as desired.

The method of invention may be used in a variety of ways depending on the goals of the design engineer. FIG. 6 shows a variant on the above method used to generate estimates based on RF measurements. A 3-D database of the environment must still be generated in function block 10. Field measurements are collected in function block 12. The RF measurement data are then incorporated into the drawing of the environment in function block 61. The design engineer may then generate estimates of power level and location of potential transmitters in function block 62.

FIG. 7 shows a variant of the method used to achieve optimal prediction accuracy using RF measured data. Once again, a 3-D database of the environment is generated in function block 10. However, before collecting field

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measurements, the design engineer creates a channel plan with "virtual" macrocell locations and power levels in function block 71. The field measurements are then collected in function block 12 and the "virtual" locations of interfering transmitters can be determined in function block 72. The best propagation parameters are then matched with measured data from the interferers in function block 73.

A more detailed description of the method for prediction used in the present invention is now described. Referring to FIG. 8, the 3-D environment definition is input in function block 801. The first step required before predicting the performance of the wireless communication system is to model the wireless system with the 3-D environment. Antennas and types of related components and locations are selected in function block 802. The desired antennas are chosen from a parts list of wireless hardware devices that may include a variety of commercially available devices. Each antenna is placed at a desired location within the environment, for instance, in a specific room on a floor of a building or on a flag pole in front of a building. A number of other components may be created and placed either within or connected to each antenna system. These components include, but are not limited to: cables, leaky feeder antennas, splitters, connectors, amplifiers, or any other user defined component.

FIGS. 9A and 9B show a method for adding antenna systems to a desired environment and generally for running trade-off analyses. First, the designer positions and defines outdoor wireless communication systems, if necessary in function block 901. Next, the designer positions and defines indoor base stations in function block 902. The methods of function blocks 901 and 902 differ in that the components of indoor wireless system will typically be different than an outdoor wireless system. In both cases, the designer is guided through a series of pull down menus and point-and-click options to define the location, type of hardware components and associated performance characteristics of the antenna systems. This data is stored in a database, that also contains cost and manufacturing specific information to produce a complete Bill of Materials list automatically, to be viewed at any time.

In order to fully describe a communication system in a newly created (or to be modified) wireless or wired system, the designer specifies the air interface/technology and frequencies associated with network protocol, physical media, or a network such as a wireless system in function block 903. For a wireless system, the designer then lays out the full antenna system for the wireless network in function block 904. Components such as base stations, cabling, connectors, amplifiers and other items of the antenna system are then selected from a parts list library containing information on commercially available hardware components in function block 905. Next, the air interface and technology specific parameters are assigned and channel frequencies are customized for the wireless system in function block 906. The channel frequencies are selected from pre-assigned channel clusters and assigned to the wireless system in function block 907. An antenna system is then configured in function block 908, selecting antennas from the parts list library as described above. The antennas are placed on the floor plan in function block 909 using a point and click of a mouse or other positioning device to visually place each component in the 3-D database.

At this or any time after a component has been placed on a floor, the designer may view a bill of materials in function block 910. If necessary, the parts list may be modified to add or delete components or modify a component's cost or

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performance characteristics in function block 911. Components may be replaced or swapped for similar components for a quick trade-off analysis of both wireless system performance and overall cost in function block 912. Components may be added, deleted or modified to more fully define the wireless communications system in function block 913. The designer may redisplay the view of the environment including the wireless communication system, RF measurement data, and/or wireless system predicted performance results in a variety of forms, including 2-D, 3-D wireframe, 3-D wireframe with hidden lines, 3-D shaded, 3-D rendered or 3-D photorealistic rendering, at any time in function block 914.

Typically, a designer will add network system components in succession, where each newly placed system component connects to a previously positioned component in the network. For a wireless network, one should note that cables and leaky feeder antennas are defined by a series of vertices connected by lines representing lengths of cabling as they are placed on a floor. This is also done for fiber optic and baseband cables. Cables and leaky feeders may also stretch vertically across building floors, down the sides of buildings, through elevator shafts, etc., simply by adding a vertex in the cable, changing the vertical height, and then continuing to place cable in new locations, in function block 915. The designer does not need to manipulate a 3-D view of the environment and attempt to guide the cables vertically in the 3-D model. The designer may repeat any of the steps in this process, in any order, in the present invention.

Referring again to FIG. 8, once the 3-D environment has been defined and antennas, cables and other objects which are used in network design have been selected and located, the wireless system performance prediction models may be run in function block 803. A variety of different such models are available and may be used in succession, or alone to generate a sufficient number of "what-if" scenarios for predicting and optimizing of antenna placements and component selections.

Referring to FIG. 10, a method for predictive modeling according to the invention is shown. First, the designer selects the desired wireless system performance prediction model in function block 1001. Preferred models are:

Wall/floor Attenuation Factor, Multiple Path Loss Exponent Model,

Wall/floor Attenuation Factor, Single Path Loss Exponent Model,

True Point-to-Point Multiple Path Loss Exponent Model,

True Point-to-Point Single Path Loss Exponent Model,

Distance Dependent Multiple Breakpoint Model,

Distance Dependent Multiple Path Loss Exponent Model,

Distance Dependent Single Path Loss Exponent Model, or

other models as desired by the design engineer.

Also, models for propagation of optical and baseband signals, such as loss, coupling loss, distance-dependent loss, and gains are contemplated.

The physical and electrical properties of obstructions in the 3-D environment are set in function block 1002. Although not all parameters are used for every possible predictive model, one skilled in the art would understand which parameters are necessary for a selected model. Parameters that may be entered include:

Prediction configuration—RSSI, C/I, and/or C/N (carrier to noise ratio);

Mobile Receiver (RX) Parameters—power, antenna gain, body loss, portable RX noise figure, portable RX height above floor;

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Propagation parameters  
Partition Attenuation Factors  
Floor Attenuation Factors  
Path Loss Exponents  
Multiple Breakpoints  
Reflectivity  
Surface Roughness  
Antenna Polarization

other parameters as necessary for a given model. The designer may save sets of physical, electrical and aesthetic parameters for later re-use. If such a parameter set has been previously saved, the designer may load that set in function block 1003, thereby overwriting any parameters already in selected.

A designer then may select a number of watch points in function block 1004 to monitor for wireless system performance. Referring now to FIG. 11, there is shown a simplified layout of a floor plan with a base station 1100. The designer may use a mouse or other positioning device to point and click to any number of locations in the floor plan to select critical areas, or watch points, for monitoring. Here, for instance, four watch points 1101, 1102, 1103 and 1104 have been selected.

FIG. 12 shows a display, that lists by location, watch points selected for the current prediction. The designer may then select predictions for RSSI, signal to interference ratio (SIR) or signal to noise ratio (SNR). In addition, the designer can see changes in predicted values for each watch point in real time as the mouse is moved, or can choose to select new antenna positions specifically by clicking on a new location. As the designer repositions the mouse cursor, the antenna(s) selected prior to initiating the prediction are effectually repositioned and/or relocated according to position of the cursor. Once all watch points are selected, the prediction model is run. An alternative embodiment is that watch points could be entered and modified on the fly, as the prediction model is being run, rather than defined only prior to running the model. Another alternative embodiment is that RF values at the watch points are updated continuously as the mouse is repositioned, without a click being necessary.

FIG. 13 shows the floor plan of FIG. 11 with the initial RSSI values for each watch point 1101, 1102, 1103 and 1104 also shown. The designer may move the antenna 1100 to a new location and monitor the same watch points for coverage. FIG. 14 shows the floor plan of FIGS. 11 and 13 with the antenna 1100 moved to a new location 1400. The RSSI values at each watch point 1101, 1102, 1103, and 1104 are automatically updated with values associated with the new location of the antenna. Alternatively, the designer may choose to modify the components within the antenna system 1100 for performance or cost reasons. FIG. 15 shows the floor plan of FIGS. 11 and 13 with a base station 1100a at the same location, but with a higher performance antenna component. The RSSI values at each watch point 1101, 1102, 1103, and 1104 are again automatically updated with values associated with the new wireless system performance parameters.

Referring again to FIG. 10, for RF coverage models, the coverage areas and values are displayed in function block 1005. If so desired, the designer modifies the electrical parameters of the obstructions, or modified components of antenna systems, or modifies antenna system locations or orientation, etc. in function block 1006 before running another prediction model in function block 1001.

Referring again to FIG. 8, after running a number of models, the design engineer may determine that RF coverage is optimal in decision block 804. If so, then depending



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on the results either a change in the location of antenna(s) and components will be desired or possibly just a substitution of components without a location change. For instance, even though the coverage may be more than adequate, the total cost of the wireless system could be prohibitive. A method for optimizing the costs using a dynamic, real time, bill of materials management system is disclosed below. Regardless, if the wireless network as currently modeled is not deemed optimal, then the method would continue again in function block 802 to re-select the components.

Once the design is as desired, then the 3-D database holds all of information necessary to procure the necessary components in the Bill of Materials. The locations of each component are clearly displayed, and a visual 3-D representation can be viewed as a guide.

Once the communications system design is as desired, the database holds all of information necessary to procure the necessary components in the Bill of Materials. The locations of each component are clearly shown, overlaid with the physical environment, and a visual 3-D representation can be viewed as a guide.

#### Generating and Managing a Bill of Materials

As described above, in more detail, the invention uses 3-D computer aided design (CAD) renditions of a building, collection of buildings, or any other such environment that contains information suitable for the prediction of a communications system performance. In an RF system, estimated partition electrical properties can be extracted from radio frequency measurements already published, and/or specified by the designer at any time. Once the appropriate electrical properties are specified, an unlimited number of RF sources can be placed in the 3-D database, and received signal strengths intensity (RSSI) or carrier-to-interference (C/I) ratios can be plotted directly onto the CAD drawing.

The 3-D environment database could be built by a number of methods, the preferred method being disclosed in the co-pending application Ser. No. 09/318,841. Traffic capacity analysis, frequency planning, and Co-channel or adjacent channel interference analysis can be performed concurrently with the prediction of RSSI, C/I and other wireless system performance measures. The antenna system and bill of materials could be built by a number of methods. The preferred method for building the antenna system is described above.

As the designer builds a model of a wireless communications system in a specified environment, as described above, a full bill of materials is maintained for every drawing in the environment. That is, each drawing may contain its own unique set and arrangement of antennas, feed systems and related components representing a variation in the design of a wireless communication system. These components are drawn from a global parts list library. A number of methods could be used to generate the global parts list library, and it would be apparent to one skilled in the art that varying formats could be used.

In the present invention, the design engineer selects a specific wireless system hardware component from the parts list library using pull-down menus and displayed dialog windows. The selection criteria for a particular component is wireless system design dependent, but generally involves the desirability of a component based upon its electrical characteristics and potential effect on wireless system performance, material cost, and/or installation cost. The present invention enables the designer to narrow the focus of component selection to only those devices contained within

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the parts list library that have the desired characteristics. For example, the design engineer may choose to design a wireless system using components from a specific manufacturer or set of manufacturers that have a desirable material cost and/or electrical characteristics. In doing so, only those devices that meet the requested criteria are displayed for selection from dialog windows in the present invention.

In certain instances, the operating frequency of a wireless communication device may define the electrical characteristics of the device. For example, depending on the frequency of the radio signal passing through an amplifier, the amplifier could have a varying amount of gain. Likewise, the radiating characteristics of antennas differ depending upon the frequency of the radio signal being broadcast. Coaxial cables, connectors, splitters, and other wireless communication system hardware components can also share this property of frequency dependent performance. To accommodate this, the parts list library from which the wireless communication system components are drawn may contain frequency specific information for each component. For example, an amplifier may have its gain specified for both 800 megahertz and 1900 megahertz. If this information is available within the parts list library for a component, the present invention automatically utilizes the frequency varying performance characteristics of the wireless hardware components within the performance prediction calculations as described below. The frequency of operation, in this case, is obtained from the transmitting source that is providing the radio signal to the wireless hardware component. For example, the base station or repeater to which the wireless hardware component is attached will have a range of frequencies or channels that it operates upon. In this case, the frequency of operation of the repeater or base station determines the frequency of the radio signal input into the wireless hardware component, and the frequency of the radio signal is in turn used to determine the operating characteristics of the component.

In addition to frequency dependent characteristics, many wireless communication devices have limitations in the manner in which they may be connected within an antenna system. Certain wireless communication hardware components are incompatible with other components and may not be connected together. For example, a fiber optic cable may not attach directly to a coaxial cable. Instead, a fiber optic cable would first connect to an optical-to-radio frequency converter device, which converts the data stream from optical into a radio signal. The coaxial cable would then connect to the output port on the optical-to-radio frequency converter. In the preferred embodiment of this invention, such connectivity restrictions are specified within the parts list library. Thus, the system automatically utilizes the information to prevent the designer from interconnecting incompatible components. If the designer attempts to interconnect two incompatible components, the present invention provides appropriate warning messages to notify the designer of the error.

Practicing communication network engineers spend tremendous amounts of time in the design and deployment phase trying to configure proper connections between communication components, such as coaxial cables, optical cables, adapters, antennas, routers, twisted pair cables, leaky feeder antennas, base stations, base station controllers, amplifiers, attenuators, connector splitters, antenna systems, repeaters, switches, wireless access points, cable boxes, signal splitters, transducers, couplers, splitters, converters, firewalls, power distribution lines, hubs, and other communication components that are known and understood by

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network engineers working in the cable, optical, wireless, networking and telephone industries. Often, various manufacturers make different brands of equipment, that are designed for particular frequency bands, mounting conditions, temperature conditions, and connector types. For example, radio frequency (RF) components often have N-connectors or SMA connectors which may not be interconnected without a proper adapter, and cables must have the proper type of connector in order to properly interconnect with other components. Similar connector types and sizes of connectors and cables exist for various makes and models of optical fiber cables, baseband twisted pair and CAT-3 and CAT-5 cables, radio frequency connectors and cables, and all other components listed above. Furthermore, network designers are often concerned about specific cost limitations, not just of a single device, but a connection of components, and often the entire system design. What's more, designers must avoid the improper mismatch of physical attributes, such as the improper connection of a very heavy component (say a switch box or a power amplifier) to a lightweight mounting fixture or a lightweight cable (say RG-58/u) that is unable to support the weight, temperature, or windload, for example. Also, particular network installations may be required in environments that have small size, low temperature, low or unusual power, or aesthetic requirements, or other particular requirements that take into account the physical attributes of the components within the network design. One skilled in the art of design and deployment of communication networks is aware of other examples as taught here that typically arise in practical network design and deployment.

In addition, engineers and technicians often have particular brands or makes of products that they are required or wish to use in all of their designs. For example, their employer may insist that only certain brands be used for all deployment and design. Or, specific model numbers or series of part numbers may be required in a design. The specification and proper matching of brands or part numbers for the design of a network, which we term "brand choice", is important for desired results in many practical settings. Furthermore, components within a communications network must have compatible power connections (e.g., an RF distribution system would want to have active components that all use the same DC voltage, so that multiple power distribution lines would not have to be run), and components must be properly matched in size, weight, mounting configuration, impedance, and color. Also, designers must be sure that when they create a network design, components which they specify must have comparable maintenance requirements. For example, a designer should not create a network that requires some components to have constant maintenance, whereas others require only infrequent inspection and tuning (a mismatch in maintenance requirements).

On an even broader scale, it is helpful to have a simple checking method for making sure that components are properly designed to match the gross physical media of the various components. Some network components use and transfer or process optical frequencies (lightwaves), while others use radio frequency (RF), such as millimeter, UHF, VHF, or microwave signals, or baseband signals (VHF and below). Telephone cable, 10 baseT, twisted pair or CAT-5 type signaling is typically baseband, for example. Components which are modeled in the present invention can take in optical signals and transform them into RF or baseband signals. Similarly, some components take in RF signals and convert them to optical signals. In the design and deployment of a network, it is vital that optical cables be connected

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directly to optical sources, as opposed to RF or baseband signal sources. Otherwise, a network will not work. Other devices which take input signals that are at RF and produce output signals that are at optical frequencies exist. In addition, components that convert or transduce baseband-to-optical, or any other of a number of combinations of these various gross frequency bands. Physical media, which also may be called modality, may include the cables used in the network design, or may actually describe the processing components that receive and transmit at the different gross frequencies.

Components may not have compatible frequency ranges of operation, so that one part is designed for 800-950 MHz while another is designed for 1900-2100 MHz (or 200 nm vs. 300 nm, etc.). Components might have incompatibilities at the level of specific connectors, so that a connector on one component could connect with specific connectors on a specific component, but not with other connectors. Components also may require the connection of other specific components directly to them, or the presence of specific other components in the antenna system, RF distribution system, and power supply distribution system, in order to function correctly. Conversely, components may not allow the presence of specific other components, or of components from some manufacturers, to be connected directly to them, or even to be present anywhere in the design.

All of the above network design considerations are important for a designer or installer. Also, all of the individual connectors on each component within a network, as well as each frequency or gross frequency band used by each component and each connector on each component, needs to be properly tracked and must all be used and properly terminated for an effective network.

The above issues are all addressed in the present invention. Failure to meet any of the above desired criteria can be considered to be a "fault", wherein a fault can be detected automatically by the present invention in the design or deployment phase. Thus, desired cost, proper connectivity, proper matching of physical attributes, and proper connection of brands, part numbers, or manufacturers, can be readily detected and properly implemented with ease. Other faults, which follow the same logic as described above would fall within the scope of this invention. When proper criteria are met, a fault will not be indicated, and the components within the design are used for computation of predictions of network performance. Also, the predictions of performance in a proper design may be compared directly to other designs within the same environment, as well as with actual measured field data.

Similarly, many wireless communication devices have limitations on the signal power that may be input into them. For example, an amplifier may only function properly if the input signal to the amplifier does not exceed a certain level of power. In the present invention, the power of a signal supplied to a wireless hardware component is determined to be the output power of the radio signal leaving the device to which wireless hardware component is attached within the antenna system. Typically, wireless communication system hardware components have gains and/or losses such that when a radio signal passes through a component, the radio signal is either amplified or attenuated depending on the operating characteristics of the component and the frequency of the radio signal. For example, referring to FIG. 4, one of the omnidirectional antennas 403a is attached to a coaxial cable 402, which in turn is attached to a transmitter 107 via a splitter 401. If the transmitter 107 is transmitting with a signal power of 10 dBm, and the total loss of the

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splinter 401 is 4 dB, the input signal power into the coaxial cable 402 is 6 dBm (the signal power of the transmitter minus the total loss of the splitter). Similarly, if the total loss of the cable 402 is 2 dB, the input signal power into the antenna 403a is 4 dBm. In the preferred embodiment of the invention, the parts list library contains information regarding the restriction of input signal power into a component. This allows the system of the present invention to notify the user of the fault in the design via displayed computer dialog boxes if, given the present configuration of the antenna system that has been visually configured and interconnected in the 3-D environmental model, that the input signal power into any of the wireless communication system hardware components exceeds the limits specified in the parts list library. This immediate feedback is invaluable to the designer and provides instant recognition of potential problems in the configuration of the antenna system.

Similarly, many cable components used in wireless communication systems have limitations on the total length of any single segment of the cable. For example, a single segment of a specific fiber optic cable may not have a length exceeding 500 feet in order to maintain the integrity of the signal passing through it. In the preferred embodiment, the parts list library will contain such length limitations specified for cabling components. Therefore, if the designer visually configures a segment of cabling within a wireless communication system such that the total length of the segment exceeds the maximum cable length specified for the cable component within the parts list library, a warning message concerning this fault in the design is displayed to the designer via computer generated dialog boxes stating the error. The total length of the cable segment is determined from the manner in which the designer has positioned the cable within the 3-D environmental database. For example, referring again in FIG. 4, the length of the coaxial cables 402 in the figure is determined on the basis of their physical placement and orientation within the 3-D environmental model. This immediate feedback provides invaluable information to a wireless system designer as it prevents potential errors in the wireless communication system design. The maximum length restriction applies to all varieties of cabling components, such as coaxial cables, fiber optic cables, leaky feeder antennas, and any other type of wireless hardware cable.

Other limitations of a component may be imposed. The component may need to be within a certain distance from a base station, regardless of intervening components. A component may need to be a certain height above ground level, within a certain distance from a wall (internal or external) or from a high-voltage power supply source, or placed in a room of sufficient size. A component may be illegal for use in a given location, or unavailable from the manufacturer from a given ordering location. A component may be too large to fit through existing apertures providing access to an indoor location as modeled in the 3-D environment database above. A component may be too heavy for a floor, or too lightweight for an unattached position. A component may be the wrong size, color, or shape. A component may be unsuitable for environmental conditions at a given indoor or outdoor location. Components made by specific manufacturers may be unsuitable. Components exceeding a per-component price limit may be unsuitable for a given design; such limits may be set for a given type of component e.g. amplifier, antenna, or cable, or may be set for any type of component. One skilled in the art could formulate many other obvious attributes that could also be checked for faults in a design, in the same manner.

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A component may be marginally compatible with a given antenna system and RF distribution system for a given site. Manufacturer-specified warnings, maintained with other component characteristics in the component library, could be delivered appropriately for these situations. For example, a manufacturer may specify that a given component may be used at a given power level and perform properly, but that the engineer should be warned that the component will have a reduced operational lifetime, or may perform in a sub-optimal manner, or cause damage to other connected parts, if used at the current input signal strength level. One skilled in the art would understand that this extends to other fault warnings about other marginally suitable components.

The present invention stores these fault warnings and the relevant conditions under which the warnings apply, in the parts list library, and automatically compares the conditions in which a component is placed in an antenna system and RF distribution system in a 3-D model of a wireless network site, and if the conditions match, displays a fault warning dialog window (not shown) to the user containing the manufacturer's warning, which must be dismissed and/or printed before the engineer is allowed to proceed with the design.

In the present invention, a cost limitation may be imposed on a given design, such that when the engineer places a component which would cause the total cost of the installation, or a portion of the installation (which is tracked in real time as indicated above) to exceed the limit, a fault warning is given. At this point, components which are relatively expensive, or inexpensive components appearing repeatedly in the design, might be identified automatically by the system as candidates for replacement for cheaper parts.

FIG. 19 shows a high level schematic of one mechanism which may be used to provide the design engineer with information on system performance and cost information. In block 1800, he selects components which will be used in the computerized model of the physical environment in which the communications network is or will be installed. There will be a plurality of different types of components which can be selected (e.g., splitters, antennas, transmitters, base stations, cables, etc.), and there will be a plurality of models of the types of components selected (e.g., various types of fiber optic cables, coaxial cables, antennas, etc.). The components will have various attributes 1802 (e.g., type of signal carried (i.e., optical or radiowave), maximum propagation length (for cables), etc.), frequency characteristics 1804 (e.g., electrical properties of a component at two or more frequencies, etc.), and cost 1806 information associated with one or more components which are selected in decision block 1800. The selected components will then be displayed on the computerized representation of the physical environment in which the communications system is or will be installed in block 1808. The system will automatically determine, based on the attributes 1802, whether the components selected can properly work together as intended by the designer or whether the components will satisfy all of the demands required of them in the communications system designed by the designer or any other error which may be present in the communications network at decision point 1810. If the communications network will not perform properly, the designer will be notified of the fault(s) in the design by a display on the screen, audible warning, or other effective means at block 1812. This will allow the designer to go back and select more suitable components. If there are no faults in the design proposed by the designer, one or more prediction models will be run at block 1814, and the results



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of these calculations will be displayed to the designer at block 1816. If changes in frequency parameters are to be considered in the prediction models, this can be done at block 1818. If desired, the cost of the componentry used in the communications network designed by the designer can be provided in a bill of materials at 1820.

In addition, in the preferred embodiment the parts list library contains specifications for compound components, hereafter referred to as "component kits." A component kit is a predefined group of select individual wireless communication components which may or may not be partially or wholly interconnected and arranged. Component kits are specified separate from a 3-D environmental model and are not related to the physical layout of a facility. For example, a component kit could consist of a specific splitter connected with a specific cable, which in turn is connected with a specific antenna. The component kit does not define where in the 3-D environmental model the splitter, cable, and antenna are positioned, but simply identifies that they are connected or assembled together. The designer may then select the component kit itself in exactly the same manner as any other individual hardware component and position the complete kit within the 3-D environmental model. Thus, by selecting the kit and positioning it within the 3-D environmental model, the designer has automatically selected and positioned the splitter, cable, and antenna.

An important and novel capability of the present invention is the ability to provide communication network performance predictions that use the component kits, and to allow such predictions to be compared with measured network data. In practice, actual communication networks may be configured using system components which are configured in a specific manner, and this specific physical and electrical representation may be done approximately or completely in its entirety by a component kit. Component kits also contain much more detailed information of each component or subsystem within the kit, such as physical media specifications for proper gross frequency interconnection, physical attributes, cost, depreciation and maintenance schedule information, so that proper interconnections within a kit, and from one or more kits to another kit, or from one or more kits to a network, may be made without a "fault", as described herein. Measurements made from actual systems comprised of components that are modeled either exactly or approximately in a component kit within the present invention may be displayed, stored, and compared directly to predictions made by systems designed with the component kit.

Referring to FIG. 20, there is shown a representation of the component kit computer editing window in the preferred embodiment of the invention. In FIG. 20, a component kit named "Component Kit #1" 1001 is shown. The component kit represents five individual components that are interconnected in a certain fashion. A coaxial cable 1002 is connected with a splitter 1003. One output connector of the splitter connects to an antenna 1004, while the other output connects to a leaky feeder antenna 1005. The leaky feeder antenna then terminates antenna 1006. The computer editor window 1007 graphically portrays the interconnection of the various components, and enables the designer to add or remove components to the component kit. Once created, the component kit 1001 can be selected and positioned within the 3-D environmental model just as any individual component. For example, FIG. 21 shows each of the components 1002-1006 of component kit 1001 positioned in one room of a three dimensional floor plan. The design engineer can then connect other components in the communications network,

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but also may select other groups of components or "component kits" for use in the facility defined by the three dimensional floor plan (or multistory facility or campus wide communications network). This enables the designer to quickly place multiple components in the 3-D environmental model by enabling the multiple components to be selected as placed as a single component.

Once a desired component is selected by pointing and clicking with a mouse or other input device (components and component kits may be imported, exported, and exchanged electronically and textually between users in the preferred embodiment of the invention), the design engineer may position the component within the three dimension environmental database. This process involves the design engineer using the mouse or other input device to visually identify the desired location for the component by clicking (or otherwise identifying) positions within the 3-D environmental database. For example, an antenna component could be placed within a specific room of a building, atop a flag pole on the side of a building, in the center of a park, or any other location deemed reasonable by the designer. In similar fashion, hardware components that span distances (e.g. coaxial cable, fiber optic cable, leaky feeder antenna, or any component having substantial length) are selected and positioned within the 3-D environment by clicking with the mouse or other input device to identify the vertices (or end points) of the component where each pair of vertices are connected by a line segment representing a portion of cable. Thus, while certain components, such as point antennas or splitters, for example, require only a single point in the 3-D environment to identify placement in the wireless communication system, other components such as distribution cables or distribution antennas require the identification of multiple points joined by line segments to identify placement. In the present invention, unique graphic symbols are utilized to represent each wireless system component and overlaid onto the three-dimensional environmental database enabling the designer to visualize the wireless communication system as it would exist in the physical world. As an example of the graphical display and shown only in two dimensions for convenience, FIG. 4 displays a base station 107 connected via two coaxial cables 402 to two indoor point antennas 403a and 403b.

The present embodiment of the invention provides and links information relating to wireless system component dependence. Such dependencies may include but are not limited to impedance matching of adjoining components, maximum run length, proper termination, or some other fault, as described herein. Certain components in the parts list library may require pre-existing components to have been positioned within the 3-D environmental database before they themselves may be selected and added to the wireless system. For example, a splitter or other device designed to interconnect two or more independent components may require that an existing component be present in the three dimensional database for the splitter to be connected with. In the previous embodiment of the invention, if the designer chooses to place a hardware component within the 3-D environmental database, and the desired component is dependent upon some other device currently placed in the 3-D database, the designer is prompted through a selection window to identify the dependent component and the selected component is positioned accordingly. In the previous example of the splitter component, if the designer chooses to connect the splitter onto the end of an existing cable component by identifying the cable component with the mouse or other input device, the position of the splitter



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within the three-dimensional database is automatically assigned to be the end of the identified cable. In this way the invention helps prevent the user from creating faulty designs. Wireless system components that do not have such dependencies (e.g., base station transceivers) may be freely positioned anywhere within the 3-D environmental database that is deemed suitable by the designer. As this description is specific to one particular implementation, one skilled in the art could see how different implementations could be developed and practiced within the scope of this invention.

In the preferred embodiment of the invention, if the wireless communication hardware components have information specified within the parts list library detailing restrictions on, for example, maximum input signal power, maximum length, or connectivity restrictions, the present invention will notify the designer immediately if any of these restrictions or limitations are exceeded during the course of the design. This notification of a potential fault occurs via computer generated dialog boxes containing textual warning messages detailing the restriction or limitation being exceeded with the present configuration of the wireless communication system within the 3-D environmental model.

Using the preferred embodiment of the invention, a designer can model and represent, visually as well as mathematically, complex wireless communication systems involving any number of individual hardware components selected from the parts list library, interconnected with and linked to one another to form complete antenna systems. As each component has associated characteristics regarding electrical properties (e.g. gain, noise figure, attenuation) and cost, the addition, removal, or change of any component directly impacts both the performance of the wireless system and the overall system cost. With the preferred embodiment of the invention, this information is updated in real-time as the designer makes changes to the wireless system. If a wireless communication system includes a specific hardware component, the present invention retrieves the associated electromechanical characteristics and other pertinent information from the parts list library entry that has been specified for the component. This information is stored in a database and is then used to quantify the effect that the component has on various aspects of wireless system design parameters or performance. For example, if the parts list library information for a specific cable indicates that the attenuation loss of the cable is 3.5 dB per 100 meters, and the designer has added a 200 meter segment of the cable to the wireless communication system, the present invention combines the information regarding the placement and length of the cable in the 3-D environmental database with the attenuation loss information from the parts list library to determine a total attenuation loss of 7 dB for the cable. Furthermore, the noise figure and other related qualities of the cable is also computed based upon well known communication theory. If the designer then adds an amplifier to the wireless system and connects it onto the end of the cable as described above, the invention retrieves information regarding the amplifier from the parts list library to determine overall gain of the wireless distribution system. If, for instance, the selected amplifier has an associated gain of 10 dB and some specified noise figure, the present invention combines the characteristics of the interconnected cable and amplifier to determine a total gain of 3 dB for the combined components, and a new system noise figure. If the designer edits or alters component information in the parts list library, this is automatically reflected in the wireless system performance prediction. For example, if the amplifier in the

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example above has the gain associated with it edited in the parts list library and changed from 10 dB to 15 dB, the combined system characteristics, which may include but are not limited to system gain and system noise figure, of the cable and amplifier from the example are automatically recalculated, resulting in an overall gain of 8 dB instead of 3 dB. Similarly if the cable is repositioned such that its overall length is altered or replaced with a different component from the parts list library, the effect of doing so is automatically recalculated and reflected in all future operations.

As mentioned previously, the Parts List Library preferably contains information regarding the frequency dependent nature of a wireless system component, the operating characteristics of the component utilized during the calculation of gains, losses, noise figure, or any other qualities that utilize the frequency of the input signal into the component to determine the specific set of operating characteristics for the component. If the component does not have a set of parameters defined for the desired operating frequency, the present invention searches for and uses the set of operating parameters specified for the frequency closest to the actual frequency of the input signal. This is a very powerful feature of the present invention as it enables a designer to select components for use in a wireless communication system without the need to worry about the operating parameters of the component relative to the operating frequency of the wireless communication system. The present invention automatically uses the best set of frequency dependent parameters specified for each wireless hardware component based on the frequency of the input signal to the component.

The Parts List Library, or component library, of the present invention also contains information regarding operating characteristics of a component which depend on some combination of the frequency of the input signal to the component, the connector on the component to which the input is applied or through which output is passed, and the direction of the signal, i.e., forward link from the base station to the mobile receiver or reverse link back to the base station from the mobile receiver. The preferred embodiment specifies a coupling loss that applies to a particular component, for a particular frequency range and modality, for a particular connector on the component, for a particular directionality of signal (i.e., forward link or reverse link). A different coupling loss is specified explicitly (or may be derived automatically) for each combination of connector, supported frequency band (of which a given component may have many), and directionality. These values are preferably applied automatically in real time to the aforementioned system performance predictions, according to the active frequency of the signal arriving at and/or leaving a component, the connector on which the modeled signal arrives at and/or leaves the component, and whether the forward link or reverse link performance is being evaluated. One skilled in the art could implement additional specifications dependent on combinations of the frequency, connector, directionality, or other aspects of the signal applied to a component.

Although the given example is in terms of simple gains and losses of the individual wireless components, one skilled in the art could apply this same method to any other electrical, electromechanical, financial, aesthetic or other quality associated with components in the parts list library and the overall system in a similar fashion.

A preferred Parts List Library is designed to be generic and applicable to any type of wireless communication

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system component or wireless communication system design methodology. There are eight basic categories of components in the preferred parts list library utilized in the preferred embodiment, although more categories could be added, as desired:

1. Amplifiers/Attenuators—generally speaking, devices that either boost or decrease the strength of radio wave signals;
  2. Connectors/Splitters—generally speaking, devices that connect one or more components to one or more additional components;
  3. Cables—various types of cabling (e.g., fiber optic cable, coaxial cable, twisted pair cable, etc);
  4. Manufacturer-Specified Point Antennas—any antenna that is manufactured and whose manufacturer has supplied information with regard to the radiation pattern of the antenna. The radiation pattern of an antenna describes the manner in which radio signals are radiated by the antenna. Antenna manufacturers supply radiation pattern information regarding their antennas so that wireless system designers can maximize the effectiveness of antenna deployments;
  5. Generic Point Antennas—any generic or idealistic antenna (that is, an antenna that may not be physically realizable or has a generic radiation pattern);
  6. Leaky Feeder Cabling/Antennas—a type of antenna that takes the form of a specialized coaxial cable;
  7. Base Station/Repeater—the controlling portion of the wireless communication system. The base station manages all communication taking place in the wireless network;
  8. Component kit—one or more individual components interconnected or grouped interconnected together to form a compound component (this preferably being done within the discretion of the design engineer by selecting amongst all or some of the components in the Parts List Library to define one or more component kits made of selected components). The component kit is referenced as a single hardware component and enables the designer to quickly add and manipulate multiple wireless hardware components. It preferably has no directly assigned electromechanical properties defined in the Parts List Library; however, the individual hardware components contained within the component kit retain all electromechanical properties assigned to them within the Parts List Library; and
  9. Other—Any component that does not belong in one of the above categories.
- Each component has a variety of associated values. These include, but are not limited to:
- Manufacturer Name;
  - Manufacturer Part Number;
  - User-supplied Description;
  - Frequency range at which part has been tested;
  - Attenuation/Amplification;
  - Number of Connections;
  - Physical Cost (material cost of component);
  - Installation Cost;
  - Antenna Radiation Pattern;
  - Maximum input signal power;
  - Maximum length (for cables);
  - Modality of component type (e.g., optical, radio signal, etc.)

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Note that many or all of the associated values listed above could vary depending on the frequency of the input signal to the component. They may also depend on the combination of input signal frequency, connector on the component to which the signal is applied or via which the signal exits the component, and whether the signal is a forward link signal originating at the base station, or reverse link signal originating from a user of the system. The parts list library utilized in the preferred embodiment of the invention allows the amplification/attenuation, radiation pattern, and maximum input signal power to be identified for specific frequencies of frequency ranges for each wireless hardware component. The coupling loss varies by frequency, connector, and direction of signal (forward or reverse link), in the preferred embodiment.

Base stations and repeater components have a number of additional parameters associated with them, including, but not limited to:

Technology/Air Interface—identifies the wireless technology employed by the base station (e.g., AMPS ("analog cellular"), IS-136 ("digital cellular"), IEEE 802.11 ("wireless LAN"), etc.);

Frequency/Channel Assignments—identifies the radio frequencies/channels this base station can utilize; and

Transmit Power—the amount of power the base station is broadcasting.

An excerpt from the preferred embodiment of a parts list is shown below.

```

<ComponentSpec>
  <databaseKey>5110</databaseKey>
  <name>CJ[CDATA[Ultraflexible Series Cable]]</name>
  <type>CABLE</type>
  <manufacturer>CJ[CDATA[Bob's Cables and
    Connectors, Inc.]]</manufacturer>
  <partNumber>CJ[CDATA[Model 21-A]]</partNumber>
  <purchaseCost>0</purchaseCost>
  <installationCost>0</installationCost>
  <maxLength>none</maxLength>
  <fileDescriptor>CJ[CDATA[N/A]]</fileDescriptor>
  <otherInfo>CJ[CDATA[N/A]]</otherInfo>
  <connectorCount>2</connectorCount>
  <bandList>
    <BAND>
      <modality>R</modality>
      <minFreq>4e+008</minFreq>
      <maxFreq>4e+008</maxFreq>
      <inputSignalMaxFwd>none</inputSignalMaxFwd>
      <inputSignalMaxRev>none</inputSignalMaxRev>
      <outputSignalMaxFwd>none</outputSignalMaxFwd>
      <outputSignalMaxRev>none</outputSignalMaxRev>
      <insertionLoss>7.42</insertionLoss>
      <associatedConnector>
        <number>0</number>
        <couplingLossFwd>0</couplingLossFwd>
        <couplingLossRev>0</couplingLossRev>
      </associatedConnector>
      <associatedConnector>
        <number>1</number>
        <couplingLossFwd>0</couplingLossFwd>
        <couplingLossRev>0</couplingLossRev>
      </associatedConnector>
    </BAND>
  </bandList>
  <BAND>
    <modality>R</modality>
    <minFreq>4.5e+008</minFreq>
    <maxFreq>4.5e+008</maxFreq>
    <inputSignalMaxFwd>none</inputSignalMaxFwd>
    <inputSignalMaxRev>none</inputSignalMaxRev>
    <outputSignalMaxFwd>none</outputSignalMaxFwd>
    <outputSignalMaxRev>none</outputSignalMaxRev>
    <insertionLoss>7.87</insertionLoss>
  </BAND>

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-continued

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<associatedConnector>
  <number>0</number>
  <couplingLossFwd>0</couplingLossFwd>
  <couplingLossRev>0</couplingLossRev>
</associatedConnector>
<associatedConnector>
  <number>1</number>
  <couplingLossFwd>0</couplingLossFwd>
  <couplingLossRev>0</couplingLossRev>
</associatedConnector>
</BAND>
<BAND>
  <modality>R</modality>
  <minFreq>7e+008</minFreq>
  <maxFreq>7e+008</maxFreq>
  <inputSignalMaxFwd>none</inputSignalMaxFwd>
  <inputSignalMaxRev>none</inputSignalMaxRev>
  <outputSignalMaxFwd>none</outputSignalMaxFwd>
  <outputSignalMaxRev>none</outputSignalMaxRev>
  <insertionLoss>20</insertionLoss>
  <associatedConnector>
    <number>0</number>
    <couplingLossFwd>0</couplingLossFwd>
    <couplingLossRev>0</couplingLossRev>
  </associatedConnector>
  <associatedConnector>
    <number>1</number>
    <couplingLossFwd>0</couplingLossFwd>
    <couplingLossRev>0</couplingLossRev>
  </associatedConnector>
</BAND>
</bandList>
</ComponentSpec>

```

This excerpt from the parts list of the present invention is the complete specification of a single component. The excerpt is in XML format, and each element of the specification is labeled with XML tags. The <ComponentSpec> tag begins the component, the <databaseKey> tag indicates the internal database key used to index the part, and the </databaseKey> ends the value for the internal database key. Similarly, the specifications include the manufacturer identified by <manufacturer>, the part name identified by <name>, and so on. There is also a list of frequency bands, marked off by a <bandList> tag. Each band, demarcated by a <BAND> tag, contains specifications which apply only when the signal applied to the component is closest to the particular band. For a band, the modality (e.g. optical, RF, baseband, CAT-5) is indicated with a <modality> tag, and symbolized by 'R' for RF, 'O' for optical, etc. The minimum and maximum frequency that bound the band are marked by <minFreq> and <maxFreq> tags; the signal maxima for input and output, forward and reverse link, respectively, for the band are also defined, as is the insertion loss for the band. Finally, a list of connectors supported by the band in question appears, marked by an <associatedConnector> tag. Each set of specifications for an associated connector include the connector number as an identifier, and a separate coupling loss for the forward link and for the reverse link, identified by the <connectorNumber>, <couplingLossFwd>, and <couplingLossRev> tags.

Thus the present invention defines specifications dependent on the frequency alone; dependent on the frequency and the component's connector; and dependent on the frequency, the connector, and the link direction, whether forward or reverse.

The parts list can be easily modified by a design engineer as new components are placed on the market, removed from the market or re-priced. The ability to maintain a unique equipment list for each drawing enables the designer to carry out rapid design analyses to compare and contrast the

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performance and cost of different vendor components. The impact of utilizing a specific component in terms of both cost and wireless communication system performance can be seen immediately using the present invention. Information that can be tracked with the bill of materials includes the manufacturer and part number, physical and installation cost, RF loss characteristics, connections, and the frequencies for which the component is valid. In addition, a rich set of customization features is utilized to enable the designer to tailor the parts list library to suit the needs of the target application. Moreover, as components with associated length data, such as cables or leaky feeder antennas, are created, stretched, moved or modified, their associated costs and impact on wireless system performance are automatically updated in the bill of materials to account for the change in length. Furthermore, the parts list is stored as an integral part of the drawing database, allowing the user to recall and archive a system design and all of its particulars. In addition, the wireless communication system performance may be recalculated immediately, using either a standard link budget equation, noise figure equation, or some other metric such as bit error rate or network throughput. This recalculation uses the specific, perhaps frequency specific electrical specifications of each component in the system, which are also stored in the bill of materials.

Referring again to the drawings, and more particularly to FIG. 16, there is shown an example of a bill of materials summary for a drawing. A description of the base station "MACROCELL" 1610 is shown to identify the antenna system for which the summary is shown. The first component 1611 is a PCN Panel 1710-1990 92 Deg 9.00 dB Gain point antenna manufactured by Allen Telecom. One should note that the component cost 1612, sub-total cost 1613 and total system cost 1614 is \$0.00. This shows that the designer has not yet updated the parts list library with current costs. When the list has been updated, the summary will automatically show component costs as well as sub-totals and totals for all base stations and components in the drawing.

FIG. 17 show a bill of materials where costs have been entered into the parts list database. Another component 1720 has been added to the "MACROCELL" base station, also. The costs of each component 1612a and 1721 are now shown. Sub-total 1613a and Total costs 1614a are also shown.

Referring now to FIG. 18, the general method of the invention is shown. As previously described, first the designer must create a database defining the desired environment in function block 180. A preferred method is disclosed in the co-pending application Ser. No. 09/318,841. A database of components is then developed in function block 181. In the case of wireless communication networks, a preferred method is described above. The creation of these components will automatically generate a parts list categorized by base station and antenna system. A bill of materials may be displayed at any time in function block 182.

In order to optimize the design of the wireless communications system and ensure adequate antenna coverage, the designer runs a series of prediction models and optimization techniques in function block 183. A preferred method for running predictions is described above. This method allows the designer to see, in real-time, changes in coverage, generally, and for specifically chosen watch points, as antennas are repositioned or reoriented. The designer may choose to add, delete or substitute components in function block 184 and then re-run the models again in function block 183. Each time the designer makes a modification in the system to improve performance, the bill of materials is automatically



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updated. The designer may run the prediction models in function block 183, and determine if the wireless system, as designed, is adequate in terms of performance and cost. If not, the designer can choose to modify components using cost or component performance considerations. Performance parameters may be entered to enable the designer to choose substitute components from a list that contains only those components that would not degrade the performance of the overall system. Note that in the preferred embodiment, the prediction or system performance models are recomputed upon user demand, but that it would be apparent to one skilled in the art to also have models recomputed instantly ("on-the-fly") as new components are added or subtracted from the bill of materials.

The integration of the bill of materials and component performance specifications is key to providing a quick and efficient method to design high performance wireless communication networks that are within budget. In addition to individual component physical and installation costs, a collection of components that may be interconnected or possibly used within a common network may also be specified. Such components from a component kit may be used in a design, and also may be considered for physical and installation cost. Moreover, within a bill of materials containing a list of network components, there may also be a tabulation, computation and storage of other important cost information for some of the components, such as cost depreciation values, or schedules for depreciation of particular components or groups of components. Such information may be available for only certain components within a network or within a parts list provided by a particular manufacturer. In addition, maintenance schedule information, which specifies the particular period or dates during which routine maintenance is required, may be included within the description of components within a bill of materials, to help the maintenance staff to properly maintain the designed network.

While the invention has been described in terms of its preferred embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method for designing or deploying a communications network, comprising the steps of:

providing a computerized model which represents a physical environment in which a communications network is or will be installed, said computerized model providing a display of at least a portion of said physical environment;

providing performance attributes for a plurality of system components which may be used in said physical environment, a number of said system components having associated with them frequency dependent characteristics;

selecting specific components from said plurality of system components for use in said computerized model; representing said selected specific components in said display;

running prediction models using the computerized model and said performance attributes to predict performance characteristics of a communications network comprised of said selected specific components, said prediction models utilizing said frequency dependent characteristics in calculations which predict said performance characteristics of said communications network.

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2. The method of claim 1 wherein said frequency dependent characteristics define electrical properties of said system components at at least two different frequencies.

3. The method of claim 1 further comprising the step of generating a bill of materials containing cost information for said selected specific components utilized in said communications network.

4. The method of claim 3 wherein said cost information comprises a maintenance schedule for selected specific components.

5. The method of claim 1 wherein said display is three dimensional.

6. The method of claim 1 wherein said system components allow converting between radio frequency and optical frequency.

7. The method of claim 1 wherein said system components allow converting between optical frequency and base-band frequency.

8. The method of claim 1 wherein said system components allow converting between radio frequency and base-band frequency.

9. The method of claim 1 further comprising the step of identifying errors in physical media connections for two or more specific components selected in said selecting step.

10. An apparatus for designing or deploying a communications network, comprising:

a means for providing

(I) a computerized model which represents a physical environment in which a communications network is or will be installed, said computerized model providing a display of at least a portion of said physical environment, and

(II) performance attributes for a plurality of system components which may be used in said physical environment, a number of said system components having associated with them frequency dependent characteristics;

a means for selecting specific components from said plurality of system components for use in said computerized model;

a means for representing said selected specific components in said display; and

a means for running prediction models using the computerized model and said performance attributes to predict performance characteristics of a communications network comprised of said selected specific components, said prediction models utilizing said frequency dependent characteristics in calculations which predict said performance characteristics of said communications network.

11. The apparatus of claim 10 further comprising a means for generating a bill of materials containing cost information for said selected specific components utilized in said communications network.

12. The apparatus of claim 11 wherein said cost information comprises a maintenance schedule for selected specific components.

13. The apparatus of claim 10 wherein said display is three dimensional.

14. The apparatus of claim 10 further comprising a means for identifying errors in physical media connections for two or more selected specific components.

\* \* \* \* \*

# EXHIBIT D



US006973622R1

(12) **United States Patent**  
**Rappaport et al.**

(10) Patent No.: US 6,973,622 B1  
(45) Date of Patent: Dec. 6, 2005

- (54) SYSTEM AND METHOD FOR DESIGN,  
TRACKING, MEASUREMENT, PREDICTION  
AND OPTIMIZATION OF DATA  
COMMUNICATION NETWORKS

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- (\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 724 days.

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- (22) Filed: Sep. 25, 2000

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G06F 15/16

- (52) U.S. Cl. .... 715/735; 715/736; 703/21;  
703/22; 709/221

- (58) Field of Search ..... 703/2, 3, 5, 21,  
703/22; 455/33.1, 33.4, 564, 446; 345/133,  
202/186; 715/735, 736, 734; 709/221, 222

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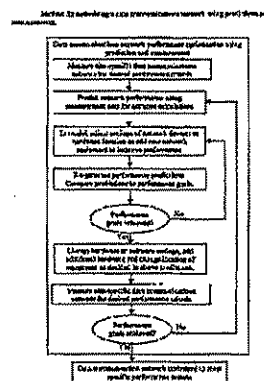
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## (57) ABSTRACT

A system and method for design, tracking, measurement, prediction and optimization of data communications networks includes a site specific model of the physical environment, and performs a wide variety of different calculations for predicting network performance using a combination of prediction modes and measurement data based on the components used in the communications networks, the physical environment, and radio propagation characteristics.

68 Claims, 6 Drawing Sheets



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Figure 1: Example transmission of data over a communications network

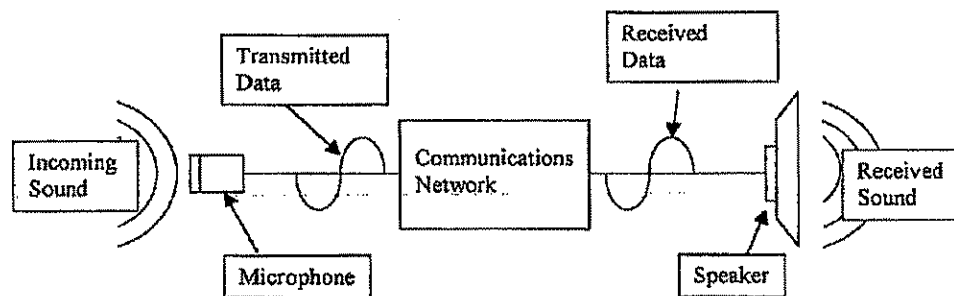
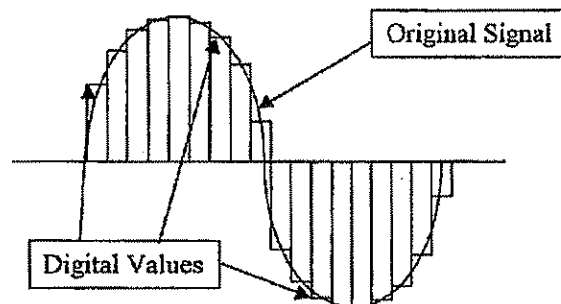


Figure 2: Creation of a digital signal from an analog signal



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Figure 3: Illustration of the difference between bits, packets and frames.

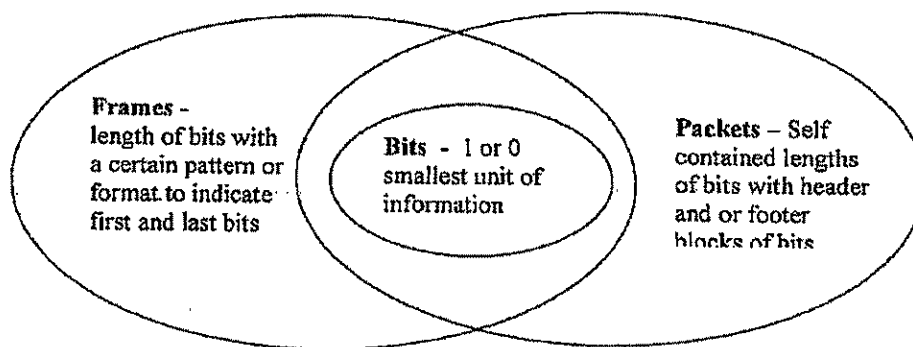
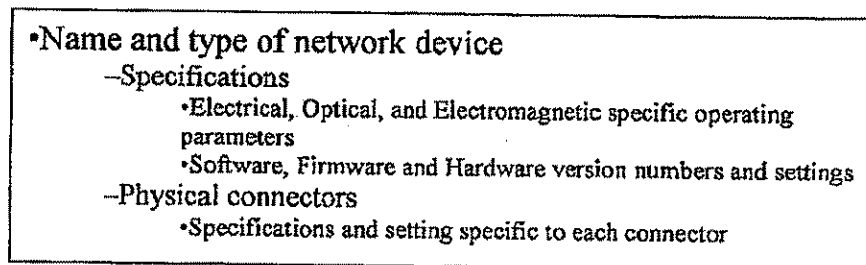


Figure 4: Illustration of the data displayed in each node of the Tree View of a data communications network.



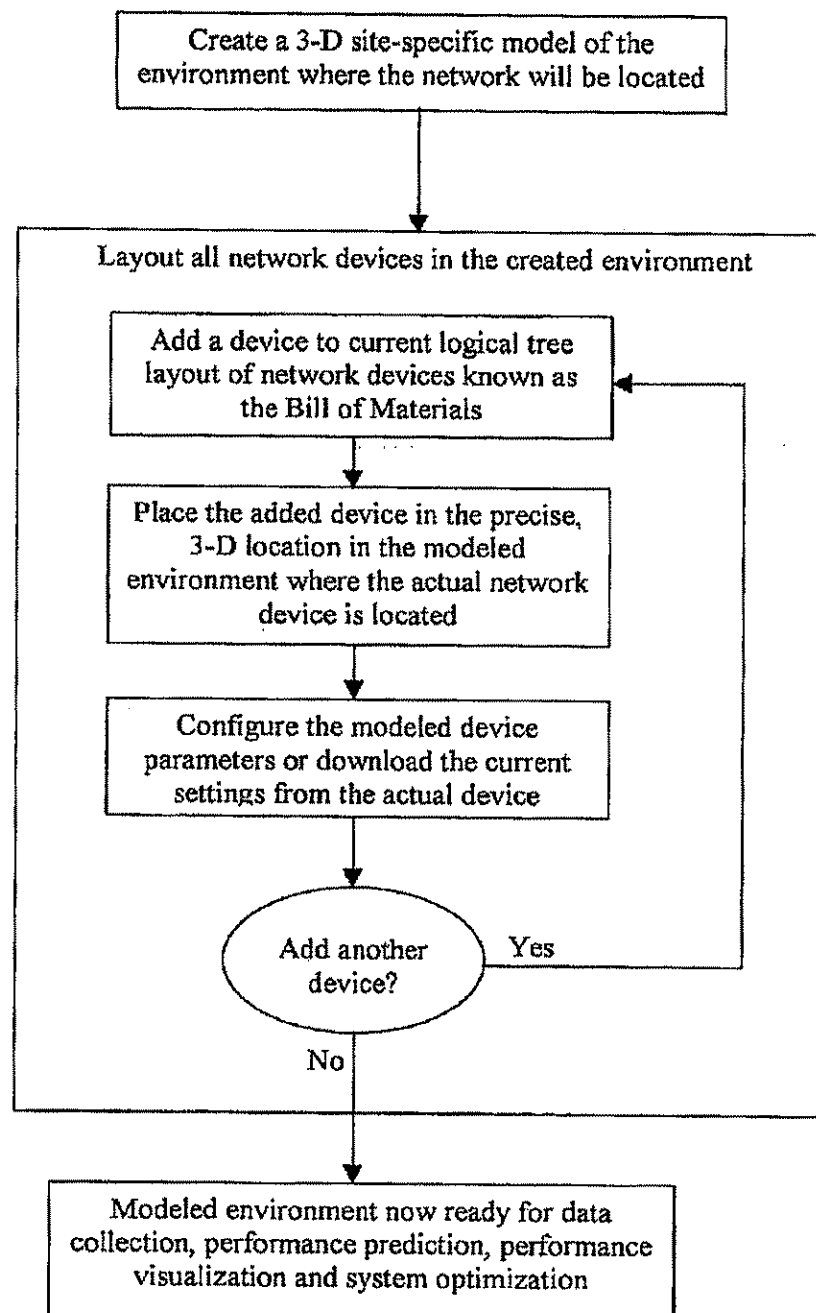
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Figure 5: Method for creating a 3-D site specific model of the environment



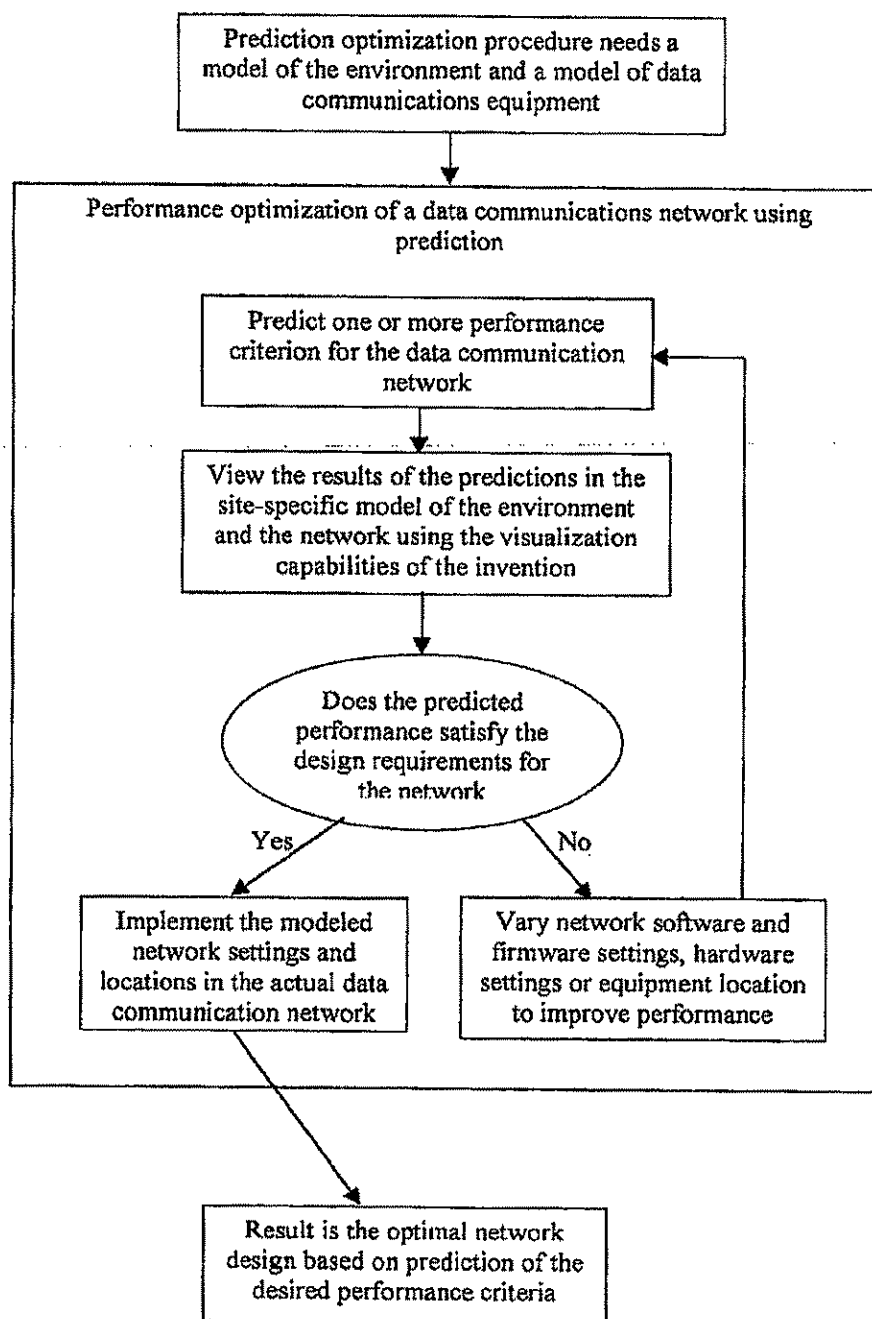
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Figure 6: Method for optimizing a data communications network using predictions



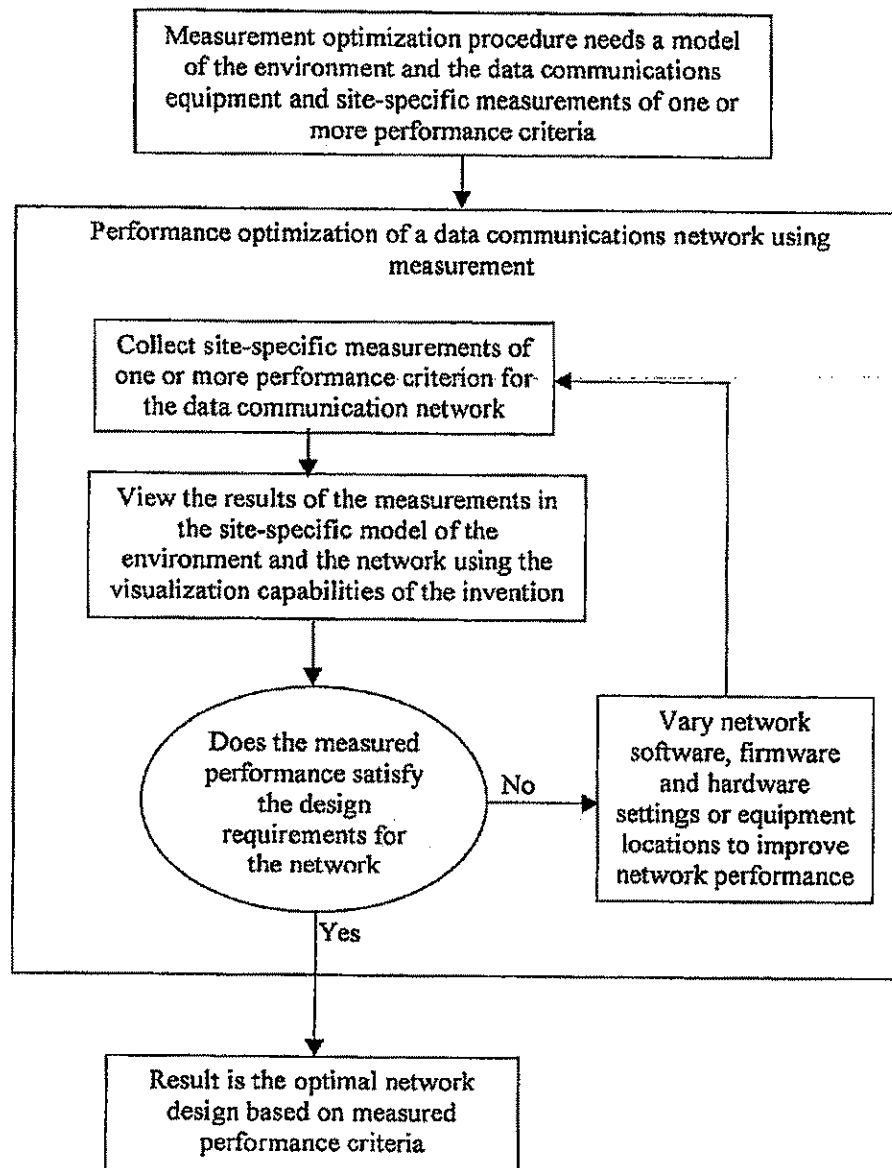
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Figure 7: Method for optimizing a data communications network using measurements



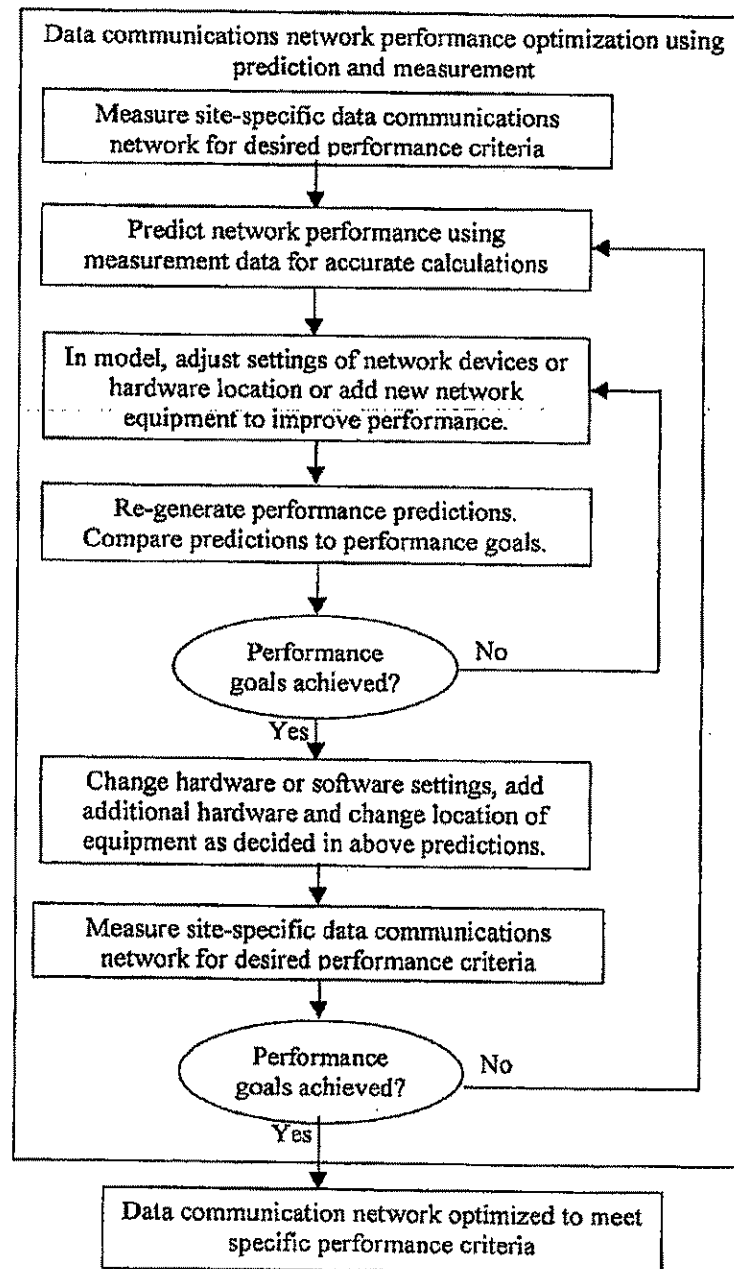
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Figure8: Method for optimizing a data communications network using predictions and measurements.





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# SYSTEM AND METHOD FOR DESIGN, TRACKING, MEASUREMENT, PREDICTION AND OPTIMIZATION OF DATA COMMUNICATION NETWORKS

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to application Ser. No. 09/318,842, entitled "Method and System for Managing a Real Time Bill of Materials," filed by T. S. Rappaport and R. R. Skidmore, now U.S. Pat. No. 6,493,679, Ser. No. 09/318,841, entitled "Method And System for a Building Database Manipulator," filed by T. S. Rappaport and R. R. Skidmore now U.S. Pat. No. 6,850,946, Ser. No. 09/318,840, entitled "Method and System For Automated Optimization of Communication component Position in 3D" filed by T. S. Rappaport and R. R. Skidmore, now U.S. Pat. No. 6,317,599. Pending application entitled "Method and System for Designing or Deploying a Communications Network which Allows Simultaneous Selection of Multiple Components" filed by T. S. Rappaport and R. R. Skidmore, Ser. No. 09/633,122, filed on Aug. 4, 2000, as well applications entitled "Method and System for Designing or Deploying a Communications Network which Considers Frequency Dependent Effects", Ser. No. 09/632,121, filed by T. S. Rappaport and R. R. Skidmore on Aug. 4, 2000 now U.S. Pat. No. 6,625,454, as pending application entitled "Method and System for Designing or Deploying a Communications Network which Considers Component Attributes", Ser. No. 09/632,853, filed by T. S. Rappaport, R. R. Skidmore, and Eric Reifsnider on Aug. 4, 2000, as well as application entitled "Improved Method and System for a Building Database Manipulator", Ser. No. 09/633,120, filed by T. S. Rappaport and R. R. Skidmore, now U.S. Pat. No. 6,721,769 and pending application entitled "System and Method for Efficiently Visualizing and Comparing Communication Network System Performance", Ser. No. 09/632,803 filed by T. S. Rappaport, R. R. Skidmore, and Brian Gold on Aug. 4, 2000, and co-pending application "Method and System for Automated Selection of Optimal Communication Network Equipment Model, Position and Configuration in 3-D", Ser. No. 09/667,689, filed by T. S. Rappaport, R. R. Skidmore, and P. SheethalNath filed concurrently, the subject matter of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The invention relates to the field of communications networks, and more specifically to the design thereof, and the measurement, visualization, prediction and optimization of the performance of data communication networks. A method and system to predict, visualize and optimize the performance of data communication networks is used to design, measure, monitor, troubleshoot and improve these data networks using an accurate site-specific model of the physical environment and the components comprising the data network.

### 2. Description of the Related Art

Communications networks are used to send information from one place to another. This information often takes the form of voice, video or data. To transmit information a communications network breaks down a message into a series of numbers. These numbers describe how to construct the information using some predetermined method. For example, the numbers could represent digital samples of the

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signal voltage that should be applied to a speaker so that the speaker reproduces the sound of the voice, as shown in FIG. 1. The information is in this case the voice message, which was transmitted over the communications network.

The process of representing information can be analog or digital. In an analog communications network the message that is transmitted is a continuously changing number. In a digital network, numbers that change at discrete, regular intervals, instead of continuously represents the message. The signal is represented by a single number each interval. This number may be converted to a binary form so that the entire message can be represented as a finite number of ones and zeros. Each binary digit in the message is called a bit. These bits are transmitted and interpreted by the receiver as the message. Binary and digital versions of a signal are shown in FIG. 2.

Data communication networks are a specific type of communication network that transmit digital information, represented as bits or bytes (a group of 8 bits), in an indoor or outdoor, wired or wireless network from a transmitter to a receiver. While conceptually simple, the means of transmitting the data from some point A to some point B are complicated and varied in implementation. Hundreds of protocols, hardware devices, software techniques and programs exist to handle how data is sent correctly and efficiently. The exact performance of a given data communication network is extremely difficult to predict or even measure because of this complexity and additionally because of the performance effects of the time varying nature of data communications networks and the channels they operate in.

Data communication network can be classified as either a circuit switched or a packet switched network. Both network types use channels to transmit information. A channel is a named communications path between users of a communications network. A channel may consist of many different individual hardware devices and is a specific route between a transmitter and a receiver. In a circuit switched network, information is transmitted by way of an exclusively reserved channel. A network channel is reserved for the sole use of a single transmission and bits are sent all at once. An example of this is the transmission of a document using a fax machine. In this case the fax machine converts the image of the document into pixels. Each pixel is a small, dot-sized, rectangular piece of the paper. Each pixel is considered to be either black or white. The data that will be transmitted is a series of bits that represent whether each dot is black or white. When the message (in this case an image of a document) is ready to be sent from one fax machine to another, a telephone circuit is dedicated to the data transfer by placing a telephone call on the plain old telephone system (POTS) communications network. The telephone line is used exclusively by the fax transmission, making it a circuit switched transmission. After establishing a connection, all data is sent from the first fax machine to the second in a single, long stream of bits. The bits in this case are transmitted as different frequency tones on the telephone line. A high pitched tone may represent a "1" while a low pitched tone may represent a "0." The receiving fax receives the bits of the message by translating the series of high and low pitch tones into data bits. The receiving fax machine will then be able to reconstruct a copy of the original document by drawing a black dot at the locations indicated by the data bits.

Packet switched networks are another type of data communication networks in which all data bits are transmitted as many, small chunks of data bits called packets and sent individually from one location to another. A packet is a

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self-contained portion of a full message that is made up of a header, data bits, and sometimes footer. The packet contains information in the header and footer that allows the data communications network to properly transmit the packet and to know of which message the data in the packet is a part. The header generally is labeled with an identifier that the network uses to forward the packet to the correct receiver. The header and footer information are often used to reassemble the packet with other packets to reform the original message and to check if errors were made in the transmission of the packet. The receiver can assemble all received packets into the original message by throwing away the header and footer headings and reassembling the data bits from all packets into the original message.

Packet switched networks are classified as connection oriented or connectionless depending on how the packets are transferred. In connection-oriented networks, a network channel is used predefined for each transmission. While this transmission can consist of multiple packets, the route from transmitter to receiver is already established, so that all packets sent on this channel can immediately be sent directly to the receiver. Whereas, in connectionless networks, packets are sent simultaneously on a shared channel in multiple transmissions. In this case, packets require an identifier that gives the address of the receiver. This address is understood by the communications network to allow the packet to be properly sent to the correct receiver. Since each packet can be transmitted separately and thus interleaved in time with packets from other transmissions, it is generally more efficient to use a connectionless transmission method when using shared network resources.

An example of a connectionless, packet-based transmission is a file transfer between two computers on an internet protocol (IP) based, Ethernet network that both computers are attached to. In this case, the file that is to be transmitted is fragmented at the transmitter into appropriate packets and labeled with the IP address, which is the identifier used by the network to forward the packet to the correct receiver. The packets are then sent from the transmitting computer to the receiving computer. The Ethernet network is capable of supporting multiple file transfers from many different computers all using the same network by controlling the flow of packets from each destination in a shared fashion. The receiver then assembles the packets into an exact copy of the original file, completing the transmission.

All data networks utilize some form of communication protocol to regulate the transmission and reception of information. A protocol is the set of rules that all hardware and software on a communication network must follow to allow proper communication of data to take place. Many hundreds of protocols are in active use today in the worldwide exchange of information. Some of these protocols, such as the Transport Control Protocol (TCP) or the User Datagram Protocol (UDP), define the way in which the network is accessed. Other protocols, such as the Internet Protocol (IP) or the File Transfer Protocol (FTP), define how messages and packets are formatted, transmitted, and received.

All data communication networks may be analyzed in some fashion to evaluate the efficiency and performance of the network as well as to confirm the network is functioning properly. In order to evaluate the functionality of these data networks, certain performance criterion is used. These performance criteria include, but are not limited to: throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter,

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bandwidth delay product and handoff delay time. Each performance criterion specifies a different performance parameter of a data communications network. These criteria are further described below.

A link is a portion of a path followed by a message between a transmitter and a receiver in a data communications network. Network connection often consists of individual devices relaying network packets from the transmitter to the receiver. This means a network connection can consist of several actual transmissions between the original transmitter and the intended receiver. Each individual relay is called a link. Typically a full network connection consists of several links. Performance criteria can be measured for each individual link.

Throughput is a measurement of the amount of data, which can be transmitted between two locations in a data network, not including header, footer or routing information bits. It is generally measured in bits per second (bps) and can be specified for hardware, software, firmware or any combination thereof that make up a connection between transmitter and receiver in a data communication network. Bandwidth is similar to throughput as it is defined for data communication networks. Bandwidth is the raw data rate that may be sustained by a given communications network and is generally slightly higher than throughput. For instance, an Ethernet link may be rated for a 10 Mbps bandwidth but a measurement of an actual file transfer may show that the rate at which data can actually be transferred between two computers using that same link is only a throughput of 6.8 Mbps as is taught in Peterson, I. L. and Davie, B. S., *Computer Networks: A Systems Approach*. San Francisco: Morgan Kaufmann Publishers, 2000.

Quality of service (QoS) is a term that is used to describe networks that allocate a certain amount of bandwidth to a particular network transmitter. Such a network will allow a transmission to request a certain bandwidth. The network will then decide if it can guarantee that bandwidth or not. The result is that network programs have a reliable bandwidth that can more easily be adapted to. When the quality of service of a connection is measured, the bandwidth that the network claims to offer should be compared to the actual bandwidth for different requested bandwidths.

FIG. 3 illustrates the difference between bits, packets, and frames. Various error rates are defined for data communication networks for bits, packets and frames. Bits are the core of packets and frames. The bits are the actual message data that is sent on the communications network. Packets include the data bits and the packet header and packet footer. The packet header and packet footer are added by communications network protocols and are used to ensure the data bits are sent to the right location in the communications network and interpreted correctly by the receiver. The packet header and packet footer are also used to ensure that packets are sent correctly and that errors are detected should they occur. Frames are simply series of bits with a certain pattern or format that allows a receiver to know when one frame begins or ends. A bit error rate is the percentage of bits that reach the receiver incorrectly or do not reach the receiver as compared to the number of bits sent. Packet error rate or dropped packet rate is the percentage of packets that reach the receiver incorrectly or do not reach the receiver as compared to the number of packets sent. A frame error rate is the percentage of frames that reach the receiver incorrectly or do not reach the receiver as compared to the number of frames sent.

Several terms are used to quantify the delay times of certain network events and may be expressed in time units

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of seconds. Packet latency is the time required to send a packet from transmitter to receiver, while Round Trip Time (RTT) is the time required for a packet to be sent from transmitter to receiver and for some sort of acknowledgment to be returned from the receiver to the original transmitter. Propagation delay, transmission delay, processing delay, and queuing delay describe the time required for different portions of a packet transmission to occur. The packet latency and round trip time of a network connection is found by summing the propagation delay, transmission delay, processing delay and queuing delay of either a one way or round trip network connection. Propagation delay is the time required for a packet to traverse a physical distance from the transmitter to the receiver. Transmission delay is the time required from when the first bit of a packet arrives for the last bit of the same packet to arrive. Processing delay refers to the time required to subdivide a data message into the individual packets at the transmitter, and to the time required to recreate the full data message from the data packets at the receiver. Queuing delay refers to the time spent waiting for shared resources to be freed from use by other transmissions. These delay times are all useful for evaluating different aspects of a data communications network performance.

Two other network performance criteria are packet jitter and bandwidth delay product. Packet jitter is the variation in the arrival time of packets that are expected to arrive at a regular rate and is typically measured in time units of seconds. A bandwidth delay product is the number of bits that can be sent from a transmitter before the first bit sent actually reached the receiver. The bandwidth delay product is found by multiplying the packet latency of a certain link by the bandwidth of the same link.

Handoffs occur in wireless data networks when a user moves out of range of one access point and into range of another access point. In this situation, the first access point must pass the responsibility of delivering data to the wireless user to the second access point. The handoff time is the amount of time required by an access point to coordinate with another access point to allow a wireless user to connect from one access point to another access point.

Software utilities and hardware devices have been developed to measure the performance statistics of data communication networks throughout the lifetime of data communication networks. Some of the more common and relevant tools are briefly described here.

A large number of command line tools are available to quickly allow a computer user to measure the approximate network performance a connection. Many command line programs are widely used on Windows, UNIX, and Macintosh operating systems and are somewhat useful for diagnostic and troubleshooting work on data networks. Examples of these command line programs include ping and traceroute. Using the ping command line program, it is possible to measure approximate data latency between different data network devices and confirm that a network connection is available between the two devices. Network connections often consist of individual devices relaying network packets from the transmitter to the receiver. This means a network connection can consist of several actual transmissions between the original transmitter and the intended receiver. Each individual relay is called a link. Typically a full network connection consists of several links. Thus, using traceroute, a probable path from relaying device to relaying device between the transmitter and the receiver can be determined so that the exact links used by the network transmissions are known. Additionally, using trac-

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eroute, the time required to traverse each individual link can be measured, and individual links that may not be functioning properly can be identified.

Various command line tools that are not included with operating systems have also been developed for somewhat more accurate, though still approximate, network measurement tasks. Some examples of these tools include tcp, and tcpdump. tcp stands for Test TCP <http://www.pcausa.com/Utilities/pcatcp.htm> and is a free utility originally written for the BSD Linux operating system, but is now available for other UNIX operating systems as well as Microsoft Windows. tcp is a basic point-to-point throughput measurement program that allows the user to control buffer sizes, various low level TCP or UDP options and control the exact data that is sent.

tcpdump is a simple utility from the class of tools called packet sniffers. Packet sniffers allow a network administrator to view the content, including header and footer information, of actual packets on a network. tcpdump allows a user to view (or "sniff") packets that are received by a host (though not necessarily intended for that host) and display all headers that match a certain user configurable pattern. tcpdump is a useful tool for troubleshooting network connections because it allows the user a direct view of the exact network traffic.

Pathchar is a UNIX command line utility which is capable of measuring the throughput between each network relay device (e.g. a router, hub or switch) in a data communications network by varying the size of the test packets that it transmits and measuring the latency of that packet transmission to various network points. The tool functions very similarly to traceroute but adds the ability to measure throughput (albeit indirectly), not just latency. Pathchar is only limited by the network hardware in the links it measures. The program needs a hub, switch or computer to transmit an acknowledgement to the test packets. This means that hidden links that do not transmit acknowledgements such as Ethernet bridges can not be measured individually by pathchar.

Several companies produce network measurement, monitoring, tracking and forecasting utilities. Some of the commonly used utilities are discussed below. The tools selected are illustrative of the state of the art of network performance measurement and asset tracking.

netViz, made by netViz Corporation, is a visual database program that allows a network administrator to track network equipment in terms of its physical location and in terms of its logical layout. This program allows the user to input the settings, locations, and configurations of the network and track the assets in your network. The tool is capable of storing this data in a two dimensional geographic map or floor plan of a building, but can not track devices in a three dimensional manner. The tool, also, does not provide network testing, measurement or monitoring features, nor does it support communication prediction or performance visualization capabilities for data communication networks. It is simply a database for accurate and useful tracking of assets.

NetIQ Corporation (was Ganymede Software, Inc.) makes a network monitoring and forecasting tool called Chariot. Chariot is able to measure throughput and many other network statistics for all popular network types, operating systems and protocols available today. The program uses a server and several small agent programs to collect data. The server checks each agent, installed on user's computers throughout the network, at regular intervals and uses them to measure network characteristics while storing



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the results on the server. These agents can measure the network connection to the server or to one another and are capable of simulating the traffic patterns of any network program and any desired usage pattern of one or more hypothetical users. The program is also capable of using the measured data to forecast expected network traffic and conditions.

Visonael Corporation (was NetSuite Development Corporation) makes several network tracking and measurement products, including NetSuite Audit, Design and Advisor. These software products are capable of automatically detecting the network equipment in use. This information as well as manually entered information can then be placed in a physical or logical diagram of the network. Visonael also offers a product to verify that networks have been configured properly and can make recommendations for configuration changes and upgrades to your network. The software products are unable to predict or measure the performance in a site-specific manner and are not capable of predicting the performance of wireless based data communication networks.

SAFCO Technologies, Inc. (now a part of Agilent Technologies) has recently created several wireless data measurement and prediction products. SAFCO makes a product called DataPrint, which is used to measure various data performance parameters of mobile telephone data networks. Their WIZARDS product also supports analysis of the effects of wireless data transmission on the overall capacity and Quality of Service for a wireless telephone network.

Wireless Valley Communications, Inc. has created a new concept called SitePlanner, which is capable of measuring and tracking the site-specific network performance of a data communications network in a physically accurate three-dimensional model of an environment. SitePlanner uses a software module called LANfielder to measure throughput, packet latency and packet error rates for any wired or wireless network connection in any Internet Protocol (IP) data communications network. Additionally, SitePlanner allows a full network to be modeled in a physically accurate manner so that precise measurements and performance predictions can be made in a site specific way. SitePlanner also allows a logical layout of a network to be stored simultaneously with a physical layout. The tool also stores both a logical interconnection and a site-specific model of any communications network using a Bill of Materials format.

In addition to network measurement and asset management tools, a good deal of research has taken place in the field of wireless data communication network performance. The research described below represent the work, which pertains to the field of this invention.

Xylomenos and Polyzos have explored the performance of UDP and TCP packets sent over several fixed, IEEE 802.11 wireless LAN network connections in Xylomenos, G., Polyzos, G. C. "TCP and UDP Performance over a Wireless LAN" *Proceedings of IEEE INFOCOM*, 1999. The research has focused on throughput limitations caused by software implementation issues and operating system shortcomings. The researchers used their own modified version of the command line utilities tcp, tcpdump and nstat under Linux to perform UDP and TCP throughput tests. All measurements were taken between three fixed locations and focused on varying the wireless LAN card types (PCMCIA or ISA) and the end-user computer hardware (i.e. Pentium 150 with 48 MB of RAM vs a Pentium 200 MMX with 64 MB of RAM). The conclusions the researchers make are recommendations for changes in the implementation of

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network protocols and linux operating system enhancements. The measurements did not consider the effects of different physical locations or the effect of variations in the wireless communications channel on the network throughput.

Maeda, Takaya and Kuwabara have published a measurement of wireless LAN performance and the validity of a Ray tracing technique to predict the performance of a wireless LAN network (Maeda, Y., Takaya, K., and Kuwabara, N., "Experimental Investigation of Propagation Characteristics of 2.4 GHz ISM-Band Wireless LAN in Various Indoor Environments," *IEICE Transactions in Communications*, Vol. E82-B, No. 10 Oct. 1999). The measurements were tracked in a small, highly radio frequency (RF) controlled environment and indicated that the wireless LAN throughput and BER were correlated to the delay spread of the wireless channel. The researchers have not however presented any way to actually predict a bit error rate or throughput from the predicted delay spread profile output by a ray tracing technique.

Duchamp and Reynolds have presented IEEE 802.11 wireless LAN, packet throughput measurement results for varying distances in Duchamp, D., and Reynolds, N. E., "Measured Performance of a Wireless LAN," *Local Computer Networks*, 1992. *Proceedings, 17th Conference on*, 1992. These measurements were performed in a single hallway. Thus, these measurements, too, suffer from failing to measure a representative environment. The researchers did not present a model to predict their results nor did they attempt to validate any sort of computer prediction technique.

Bing has also presented measured results of the performance of IEEE 802.11 Wireless LAN in "Measured Performance of the IEEE 802.11 Wireless LAN," *Local Computer Networks*, 1999. *LCN '99. Conference on*, 1999. Bing presents delay and throughput measurements as well as theoretically based throughput and delay time tabulations for various wireless LAN configurations. The results are given as optimal results, however. All measurements were performed in such a way that the wireless channel had the least possible effect on the overall throughput and delay times. Therefore, the results presented are an upper bound on best possible results and do not extend into a site-specific wireless LAN performance prediction technique.

Hope and Linge have used measurements to calculate the needed parameters for predicting the coverage area of a Wireless LAN network in an outdoor environment by using the Okumura model. The researchers have made outdoor measurements with standard IEEE 802.11 wireless LAN modems to calculate the needed parameters of the Okumura model and have presented these results in Hope, M. and Linge, N., "Determining the Propagation Range of IEEE 802.11 Radio LAN's for Outdoor Applications," *Local Computer Networks*, 1999. *LCN '99. Conference on*, 1999. Using these results, The coverage area outdoors could be calculated. However, the results do not allow the user to predict the performance in terms of throughput or latency of a wireless LAN.

Several patents related to, and which allow, the present invention are listed below:

U.S. Pat. No. 5,491,644 entitled "Cell Engineering Tool and Methods" filed by L. W. Pickering et al;

U.S. Pat. No. 5,561,841 entitled "Method and Apparatus for Planning a Cellular Radio Network by Creating a Model on a Digital Map Adding Properties and Optimizing Parameters, Based on Statistical Simulation Results" filed by O. Markus;

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U.S. Pat. No. 5,794,128 entitled "Apparatus and Processes for Realistic Simulation of Wireless Information Transport Systems" filed by K. H. Brockel et al;  
 U.S. Pat. No. 5,949,988 entitled "Prediction System for RF Power Distribution" filed by F. Feisullin et al;  
 U.S. Pat. No. 5,987,328 entitled "Method and Device for Placement of Transmitters in Wireless Networks" filed by A. Ephremides and D. Stamatelos;  
 U.S. Pat. No. 5,598,532 entitled "Method and Apparatus for Optimizing Computer Networks" filed by M. Liron et al.  
 U.S. Pat. No. 5,953,669 entitled "Method and Apparatus for Predicting Signal Characteristics in a Wireless Communication System" filed by G. Stratis et al.  
 U.S. Pat. No. 6,061,722 entitled "Assessing Network Performance without Interference with Normal Network Operations" filed by W. J. Lipa et al.  
 U.S. Pat. No. 5,831,610 entitled "Designing Networks" filed by D. L. Tonelli et al.  
 U.S. Pat. No. 5,821,937 entitled "Computer Method for Updating a Network Design" filed by Tonelli et al.  
 U.S. Pat. No. 5,878,328 entitled "Method and Apparatus for Wireless Communication System Organization" filed by K. K. Chawla et al.

An existing product, SitePlanner, described in patent application Ser. Nos. 09/352,678, 09/221,985, 09/318,842, 09/318,841, 09/318,840, and other inventions cited previously, are useful for designing, measuring and optimizing communication networks because the products can predict radio frequency effects directly relevant to any communication network for any physical location. That is, using information about the physical layout of any communications network and the configuration of its hardware, prior art can provide a visual display of the expected received signal strength intensity (RSSI), signal to noise ratio (SNR), relative received power intensity, best server, and equal power location, as well as other useful parameters for voice and data networks, for any modeled physical location. These statistics can be predicted for the forward link (from a transmitter to a receiver), or for the reverse link (replies from the original receiver to an original transmitter) directions for wireless networks. The site-specific nature of these predictions translates directly into quick and useful visualizations of the quality of a communication network. However, the prior art does not consider methods for properly modeling (e.g. predicting) the complexities that go into determining the values for actual network operating performance parameters that are simultaneously affected by multipath propagation, multiple interfering data transmissions from multiple sources, signaling protocols, equalization methods, and the like. Predicting bit error rates, data throughput, delay, and quality of service metrics in a 3-D physical model of an actual site-specific environment is a very difficult task, and one which has not been solved heretofore, since different modem vendors have different and often-times proprietary methods for mitigating or dealing with multipath, multiple access interference, protocol type, packet size, and noise. That is, the state of the art shows how to measure and display and make predictions for basic communication metrics but does not provide specific prediction algorithms for a wide range of important data network performance parameters in a reliable, site-specific manner. Simply put, a wireless network performance prediction engine, which is able to consider an accurately modeled 3-D physical environment, and which exploits knowledge of specific component layouts, is not found in the prior art and is not obvious due to the complex nature of having to account for all possible physical, electrical, and logical factors for all components in a

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network, as well as the factors within the channel of a wired or wireless network, that lead to actual network performance.

Prior published papers in the area of communications networks do not demonstrate the ability of any invention to accurately predict three dimensional, site-specific network performance criteria. The paper mentioned earlier by Macda, Y., Takaya, K., and Kuwabara, N., "Experimental Investigation of Propagation Characteristics of 2.4 GHz ISM-Band Wireless LAN in Various Indoor Environments," *IEICE Transactions in Communications*, Vol. E82-B, No. 10 Oct. 1999 has demonstrated the ability to predict the delay spread of a wireless channel and that the prediction correlates well with throughput, but the described method is not actually able to predict throughput or any other network performance criteria. While some prior art has demonstrated the ability to track network assets in a two dimensional manner with some physical accuracy, these products have not contemplated the ability to predict future network performance for similar or different physical environments (e.g. installations). Many products allow the measurement of network performance criteria, but no prior art has contemplated a 3-D representation of the physical environment with the physical installed base of components, for the purpose of predicting network performance parameters. Furthermore, no tool or invention exists that can directly measure, track the assets of, predict the network performance criteria of, and visualize the network performance criteria of a data communications network in a three-dimensional site-specific manner.

Furthermore, none of the prior art has considered an invention that can perform precise, site-specific, three dimensional performance prediction of complicated network parameters using a priori measurements from an existing network, or by using the site-specific layout details of particular components within a data communications network. Furthermore, none of the prior art has autonomously measured site-specific network performance parameters from an actual network system or subsystem using a system of agents, and then applying the specific 3-D locations and measured results of those measurement agents to create a 3-D prediction model for future network performance in the same, similar, or different physical environments. Furthermore, none of the prior art has developed a hierarchical system of measurement and prediction engines, that have the ability to measure network performance parameters in the field and have the ability to produce a predictive engine for network performance parameters that can be shared with remote prediction engines, for the purpose of measuring and predicting network performance in a 3-D site-specific manner.

The present invention extends the prior art in a non-obvious way to provide wireless and wired network performance prediction, visualization and measurement for important data communications-specific performance criteria, also called performance parameters, such as throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time in a site-specific, three dimensionally accurate manner. The invention contemplated here allows novel distributed measurement techniques for the above performance parameters. Furthermore, prediction methods for the above performance parameters are created, which use network measurements or applied values derived from other means, and which also use the

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radio frequency environment, the 3-D physical network layout, the channel propagation characteristics of a site-specific environment, and the specific physical layout of components, for the computation of predicted performance parameter values.

#### SUMMARY OF THE INVENTION

The present invention is capable of predicting, measuring, and optimizing the performance of a data communications network. The invention is capable of representing a detailed layout of a fully deployed or contemplated communications network within a physically accurate computer representation or model of a three dimensional environment. This allows the invention to store measurements and determine performance predictions within a site-specific representation of the physical environment, while using specific information about the network entities, components, subsystems, and systems used to create the actual or contemplated network. Measurement agents, with known or assigned 3-D position locations, are used to measure in-situ performance parameters that are transmitted to a server processor. The server processor has an accurate 3-D model of the environment, and is able to process the measured data, and is also able to provide predictive models using site-specific information that may be independent of or may make use of measured data. The server process is able to communicate with other server processors in a hierarchical manner, such that data fusion from many remote or collocated networks may be assembled and used for display and cataloging of measurements that may or may not be used for creation of predictive performance models. Alternatively, each server processor is able to compute predictive performance models without the use of measured data, by simply considering the site-specific layout of physical components, as well as the specific delay times, transit times, propagation effects, and multipath and noise factors within the physical network.

The invention can predict throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time in a site-specific, three dimensional model of any environment. The invention can measure and predict all of the above performance criteria and store the results in the physically accurate three-dimensional model of a data communications network and the environment in which it is installed. Further, the invention can display the measured and predicted performance criteria for any data communications network in the three dimensions, site-specific model of the environment. These capabilities provide a powerful design environment for wired and wireless networks, which allows one skilled in the art to quickly and easily design, measure, predict, optimize and visualize data network communication performance criteria in a three dimensional, site-specific manner using methods never before contemplated.

#### BRIEF DESCRIPTION OF THE FIGURES

FIG. 1: Example transmission of data over a communications network

FIG. 2: Creation of a digital signal from an analog signal

FIG. 3: Illustration of the difference between bits, packets and frames.

FIG. 4: Illustration of the data displayed in each node of the Tree View of a data communications network.

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FIG. 5: Method for creating a 3-D site-specific model of the environment

FIG. 6: Method for optimizing a data communications network using predictions

FIG. 7: Method for optimizing a data communications network using measurements

FIG. 8: Method for optimizing a data communications network using predictions and measurements.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The present invention contemplates the abilities to design, measure, predict and optimize the performance of a data communication networks. The invention uses an accurate computer generated three-dimensional model of a communications network stored in a computer database environment. The invention allows the user to place the network cables, hubs, routers, switches, bridges, wireless access points, amplifiers, splitters, antennas (point, omnidirectional, directional, leaky feeder, distributed, array, etc.) transceivers, terminators and other communications and computer networking equipment in their actual modeled physical locations. The present invention uses this highly-accurate model of the physical layout of infrastructure to allow a user to visualize, predict and optimize the performance of any communication network in any 3-D site specifically modeled physical location.

The present embodiment of the invention is capable of modeling the site-specific communications network hardware from both a logical connection and a physical location perspective. The invention uses well-known hierarchical, logical connection concepts (sometimes called topological layout) suited for data communications networks in combination with a physically accurate, site-specific model of the data communications network. Previous inventions focus on only the topological, or relational, layout of network components with one another. This invention uses specific 3-D modeling and, therefore, allows highly accurate asset management and facilities tracking of actual installed equipment while simultaneously providing for network performance prediction, measurement, and design capabilities that exploit the exact physical dimensioning of the network. In addition, the invention simultaneously stores an inventory of important network-specific and equipment-specific characterizations of all objects used in the network, such as vendor, model number, network hardware type, operating system version, firmware and software type and version. The hierarchical, tree based model of the network is termed the Layout View. The physically accurate, site-specific model of the network is termed the Site View, whereby the attributes of each device can be displayed, stored or printed by selecting a particular item or node within the 3-D environmental model. Further, network hardware and software components can be interactively replaced, removed, reconfigured or moved to a new location in real-time using either the Layout View or the Site View. Each of these ways of tracking and designing a network in a 3-D site specific model of the environment with accurate dimensioning of true spatial position are further described below and are used to create a Bill of Materials for the modeled data communications network, whereby a preferred embodiment is described in co-pending patent application "Method and system for designing or deploying a communications network which considers component attributes," filed on Aug. 4, 2000.



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An example of some of the information contained in the Layout View, hierarchical layout of a data communications network is shown in FIG. 4. In the figure, a tree structure is used to display all hardware in the network. Each node in the tree contains information which is used to track the true physical location, logical layout and electrical, optical and electromagnetic connections for the data communications network hardware as well as any version numbers and settings of software or firmware running on that network equipment and the known performance parameters of that equipment, including the device throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time.

The Site View of the invention has a physically accurate, three-dimensional modeling capability to display all network devices in a site-specific model of the environment that the network is located in. That is, the preferred embodiment of the invention allows each modeled hardware and software device to be placed in a three-dimensionally accurate manner and to track attributes of that device relevant to data communications networks. These key attributes include such items as the hardware type, hardware configuration, software type, software configuration, operating system version, as well as upper, lower and "typical" specifications for each component. These specifications may include important device or network subsystem operating parameters, such as throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time. As described below, the Site View supercedes prior art described in previous co-pending patent applications by Wireless Valley Communications, Inc by hereby considering the difficulties and solving data network prediction, design and optimization problems for more complicated data communication networks. Specifically, this new invention considers physical, site-specific modeling techniques and performance prediction methods and design methods for data network systems, both wired and wireless, which have performance characteristics that are based on much more complicated physical factors than just radio signal strength, interference, or multipath alone. In particular, for data communication networks, many additional factors, which relate to particular network equipment or modem designs, such as packet size, equalizer deployment, modulation methodology, source and error coding methods, packet protocols, as well as the number of co-channel network users, the type of persistency used for packet retransmission, or the multipath propagation effects in a wireless system, provide additional factors that must be considered in the design of a communication network that is designed for data traffic as opposed to simply voice traffic.

One difficulty that today's network designer or network system administrator faces is that most networking equipment uses proprietary, non-public methods for implementing various network devices, and these methods vary by specific vendor. Thus, it is difficult to form reliable prediction models by just using basic physical propagation models in a wireless network, for example. As data transmission technologies such as Bluetooth, DSL, Voice over IP, and future packet-based cellular radio network architectures proliferate, the ability to predict and measure specific network performance parameters will become increasingly important, and the

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ability to properly incorporate measurements into 3-D prediction models for performance parameters will be important for proper network deployment.

This invention considers attributes relevant to packet-switched data communication networks, which require more extensive and non-obvious modeling when compared to traditional cell phone or telephone voice communication systems that are circuit switched and use a dedicated single user (or bounded number of users) per assigned operating channel. Data communication networks have performance criteria that are specific to packet-based systems and that are not useful to all types of communication networks contemplated previously. For this reason, the preferred embodiment of the invention can additionally predict the throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time, based on the specific physical and spatial location of each network component, as well as the physical, electrical, and logical attributes of the specific components. The performance prediction methods take into account all devices and network equipment, including the physical locations within the 3-D modeled environment, using the constructed Bill of Materials of the network within the 3-D modeled environment, and is capable of performance predictions for any desired location in the modeled network and environment, where a location may be within a room, at a particular location in a room, within a building, or in an outdoor region of varying granularity, depending on the requirements of the user.

Prediction of throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time and other performance parameters may be carried out by predicting the performance for all wired network components separately from the performance of wireless components, and then combining the results to get the net network performance. To predict the performance of a wired communication link, it is important to combine the known effects of each piece of wired equipment for the specific network settings, also known as operating or performance parameters, such as protocol type, data type, packet size, and traffic usage characteristics, firmware type, operating system type, typical network performance characteristics, and typical, average, peak, and minimum traffic load on the network. For wireless network components, additional factors concerning propagation, signal strength, interference, and noise must be considered.

The preferred embodiment of the invention allows data communication networks to be accurately characterized for performance prediction in a number of novel ways.

First, performance prediction may be based on field measurements from an actual network, where prediction models are formed from some fit to measured data (an empirically-based model). These field measurements may be made manually, or autonomously, using data collectors, or agents, that continually measure and update the specific network performance metrics that are observed within the physical environment. These data collectors are able to measure, or are assigned, specific 3-D position locations within the physical environment, such position locations corresponding to known positions in the computer model which is used to model the physical environment of the

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network, and which are known or which are transmitted to a measurement server. The data collectors may be individuals who manually or automatically record or collect observed network performance such as one or more of the aforementioned performance parameters, or the measurement agents may be software or hardware or firmware applications that run on top of network applications for the purpose of routinely measuring for one or more of the numerous network performance parameters listed previously. The agents may be fixed, or may be portable, and may have position location devices, such as GPS or inertial navigation, or an internal map which is activated by a user, so that the position location of the measurement is sent to a server processor. The agents are presumed to have two-way communication with a server processor that may be collocated or remotely located. Measurements from one or more data collectors are routinely or periodically collected and then transmitted, either by wireless or wired means, or by real-time or stored means, to a server processor which is either collocated, or remotely located, from one or more of the measurement agents. For example, the measurements may be recorded by autonomous agents and then transmitted over a fixed network to a processor that integrates all measurements and computes statistics for observation. The measurement sources have known positions in 3-D, or may not be known and used to form a gross estimate of observed network performance. The collected measurements may be sent in real time, stored and forwarded, or sent as file transfers via many means, such as via email, over the world wide web, via wireless, wired or optical links, or in a storage device. This "in-situ" measurement data is passed, with the 3-D position location when available, to the server, which catalogues and processes the specific measurement information. Using the measurement information from the data collectors, the server is able to provide a predictive model by using knowledge of the physical 3-D environment, and by fusing the many collected inputs into a simplified model of performance that is related to the 3-D physical representation of the world.

In the preferred embodiment of the invention, the server stores and processes the physical location of all measurement devices (where available) as well as all network components and their electrical, logical and technical configuration, while also considering cost and maintenance issues associated with each network component. Using the preferred embodiment, a data communications network can be designed, deployed, tested, predicted, measured, optimized and maintained by collecting the measured data from one or more agents, and processing them at the server to determine a proper prediction engine that allows future network layout with a desired outcome prior to installation. The server engine is able to display the measured results, in a site-specific manner from each measurement agent (that has site-specific information) so that predictions may be compared to measurements on a visual display of a computer or in a stored means (such as an ASCII file comparing predicted versus measured performance parameters).

It is important to note that each measurement agent may be a server, capable of fusing measurement data with the site-specific 3-D layout of the network components and the physical environment. Therefore, each measurement agent may serve as a centralized processor, as well, so that many different physical locations of a particular network may be measured and predicted for performance. Servers may then be collocated or remotely located from the measurement agents, which collect, display, store and use the measurements to form predictive models. In the case of a remote

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server that receives measurement data from measurement agents, it is possible to remotely monitor, and then predict, the performance of a network that is physically very far from the particular server processor.

The measurement agents may be further controlled or configured by the server processor, so that the agents may be tuned or instructed to perform different types of measurements, such as different packet transmission rates, observation intervals, averaging intervals, protocol types, or other sensible changes which those skilled in the art would conceive for proper network optimization.

A second method for predicting the performance of network parameters is through the use of analytical or simulation methods. These analytical and simulation methods are well known, and relate the physical and electrical characteristics of the network channel to the physical and electrical characteristics of the various network components. Through simulation or analysis, it is possible to determine approximations or bounds on the typical values that one would expect in an actual network configuration of specific components. The present embodiment of the invention allows a user to enter the results of such calculations, so that they are applied as inputs to the prediction model. Therefore, a user of the invention may simply enter "blind" values, based on known methods, as a first guess approach to forming a prediction model of network performance. These first-guess values may then be iterated by the invention, based on feedback from the site-specific measurements of the actual network.

A measured set of data for a typical operating environment with multiple transmitters in a wireless or wired network, are recorded, stored and displayed by the invention, as taught in the previous description about the measurement agents and server processors. Then, some form of best-fit algorithm (minimum mean square, median filter, etc.) may be applied to the predictive models provided in the equations taught below to provide a table look-up for determining proper performance values (e.g. proper values for constants or functions in the performance parameter equations listed below) for a particular site-specific network design. This table look up method allows measured data to be translated into values that may then be used to drive predicted data for all subsequent predictions conducted within the same site-specific 3-D environment in which measurements were made. Alternatively, best guess performance metric values, or best guesses for the functions or constants in the equations listed below, may be fed into the invention, either manually or automatically through a storage means or via a wireless or wired means from a remote or collocated location, for a specific 3-D modeled network environment, wherein the predicted performance at any space or location with the 3-D environment is based on the first, best guess, predictive models. As explained subsequently, these initial best guess, or "blind" models may be based on simulation, analysis, or some combination thereof. The empirically-based predictive models and the initial best guess predictive models may be used in subsequent environments, different from the environment for which measurements or best guesses were made, and the invention allows a catalogue of models to be used easily by the user for subsequent network prediction or design. Measurements of actual network performance may then be overlaid and displayed and stored simultaneously with the network prediction parameters, for rapid comparison. Furthermore, optimization routines compute the best values for minimum error for new predictive models that match the measured network performance within the environment. Thus, the

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invention allows the user to relate empirically-derived predicted performance parameters or initially guessed network performance parameters within a 3-D site specific configuration of the actual installed or contemplated network, using specific information and physical locations about the network devices and by using the models for wired networks and wireless propagation, multipath, and noise. The model techniques for this invention fuse the many factors that impact network performance into simpler models that support prediction and comparison of measured versus predicted network performance for radio/wireless and wired networks. Thus, performance prediction can be ascertained and compared to measured network performance for use in ongoing network deployment.

Furthermore, by comparing measured network performance metrics to predicted metrics, the invention allows new field measurements to update the previous prediction models in a convenient method, which provides a catalogue of models that is stored and displayed to the user either locally or remotely. Alternatively, using the hierarchy of servers, it is possible to use remotely located servers which compute, transmit, or receive such measurements and predictive models for the remote use, display, measurement and storage of model parameters and results. This is particularly convenient for network administrators who wish to monitor the performance and design of networks that are physically distant from the network of interest.

Measurements of a particular device for desired performance criteria is accomplished either by using the measurement software module available in the preferred invention or by importing a log file from another software or hardware measurement tool. The measurement module within the preferred invention allows the measurement of the performance of any specific portion of a communications network using two or more software programs which are installed and run on either sides of a device or devices. These software programs are called agents. By sending test transmissions between two agents across a specific network connection the preferred invention can measure any particular performance criterion. The results of these measurements are stored for a particular portion of the network.

The preferred embodiment of the invention can also import the logfiles of other measurement programs such as traceroute to measure specific links. This functionality allows site-specific measurements made by external programs to be stored site-specifically. This is accomplished by a two-pass method described in patent 09/221,985, "System for Creating a computer model and measurement database of a wireless communication network" by T. Rappaport and R. Skidmore, filed Dec. 29, 1998. To import a logfile a user simply clicks a point in the model of the environment for each data point to assign a location for each point in the logfile.

In performing network performance measurements, especially for wireless data networks, it is important to know the difference in performance for transmission and reception. This is why the preferred invention can measure the transmission and reception components of the average network statistics. To measure the transmission direction, the size of test packets is varied. By changing the size of the packet sent and the size of the packet returned, the transmission and reception statistics can be separated. This allows a network designer to identify problems in transmission that might otherwise be masked by apparently good reception.

Network performance measurements are not useful if the measurements do not mimic the actual data traffic that a network carries. For this reason, the preferred embodiment

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of the invention is able to mimic the traffic patterns, network protocols and packet characteristics of actual data. Thus, if web browsing performance is being measured, the invention sends small packets from an access terminal to a web server and returns large packets from that server that are typical of text, image and web script file formats. By measuring the performance of such packets, the invention accumulates accurate network statistics for expected web browsing performance.

The measurements of specific traffic types may also be applied to the use of broadcast or multicast packet performance scenarios. The preferred embodiment of the invention is able to measure performance of multiple transmitters or multiple receivers or both of the same packet information. The performance of this type of transmission are different than point to point measurement because shared resources are used more efficiently in broadcast and multicast scenarios. Thus, the ability of the invention to measure network performance statistics for the overall success of the broadcast or multicast transmission and for each individual transmitter and receiver is quite powerful. This ability allows network designers to better choose which transmitters of multicasts might be redundant or which broadcast transmissions are insufficient to reach all the desired receivers.

In some data communications network, the performance of specific pieces of equipment, such as Ethernet Bridges or even a single cable, is hard to measure because it is transparent to the network layer of a data communications network. For this reason, the ability of the invention to determine the performance of a single device through extrapolation is quite useful. The preferred embodiment of the invention is able to use known performance data for specific pieces of network equipment and extrapolate the contribution of other devices in the network. Measuring and extrapolating enough individual hardware and software links can identify the performance of all network devices. The accuracy and reliability of this procedure heavily depends on an accurate and site-specific model of the data communications network, which the invention possesses.

Extending the extrapolation concept of performance evaluation to the software and hardware components of network equipment demonstrates a further capability of the preferred embodiment of the invention. The invention is able to distinguish in some cases between the performance limits due to software and those due to hardware. For example, in a situation where the transmitter and receiver are the same computer, no hardware is actually involved in the transmission. By measuring network statistics in this situation, one can quantify the performance of just the computer software. By comparing the situation where the transmitter and send are the same to a situation where the transmitter and receiver are different computers the performance of just the computer hardware can be identified. Since the performance of the software in either case will be quite similar, the performance of just the hardware in a connection between two computers can be extrapolated by assuming the software will perform similarly in either case.

Extrapolating the performance of individual network components from measured performance metrics can be time consuming. For this reason, the preferred embodiment of the invention is able to read in data results from a plethora of measurement tools, system utilities and network logfiles to a single internal format. The invention is capable of reading in the output of command line utilities such as ping or traceroute, the logfiles generated by routers and switches such as tcpdump, or even the logfiles of other commercial measurement programs, and these measurement results are



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stored for use in the predictive engine. The combination of these imported files to a single internal format allows the invention to combine many different measurements and activity logs into a single set of network statistics. This process means the invention requires fewer active measurement campaigns and more diverse and accurate data for better and more accurate network performance modeling.

Accurate, reliable representations of a data communication network require a large number of measured data points. Hence, the preferred embodiment of the invention collects a large amount of data quickly and easily using various methods as described above. The invention does this by providing remote data collection agents, which can be installed on data access terminals or embedded in hardware, software, or firmware within an actual device in the network. The remote data collection agents respond to a server program (the processing server) that controls the measurements made by the remote agent. That is, the remote agent can be directed to make a measurement to or from any other remote agent or processing server using any desired protocol, traffic type, network setting, or configuration. This process does not require any input from a human user at the remote agent's physical location. The agents simply records the data when asked with the correct settings and reports the results back to a server which stores data from all remote agents and other measurement tools. The server can generate a variety of detailed reports and use the data to make predictions about expected network performance in future. Servers can also function as agents. In this manner, servers can be organized in a hierarchy or a distributed fashion. This allows servers to report measurements to one another and make measurements using other agents or servers. A network designer at a server can then use all collected and reported data to identify problem areas such as fairness or poor distribution of broadcast data, or problem times, such as increased network activity at lunch time with a data communications network.

In order to improve the value of measurement data collected, the preferred embodiment of the invention identifies the exact (if possible) or approximate location of a remote agent. As discussed earlier, remote agents in this case can either be controlled by a user at that physical location, or controlled remotely by a server. In the preferred embodiment of the invention, the agent uses information about the network layout to identify an approximate location. Determining the nearest piece of network equipment and associating the approximate location with the precisely known location of that network equipment accomplishes this. This approximate location can be further refined using dead reckoning, clicking on a location in a map, or using the global positioning system, laser range finders or some other positioning device known now or in the future.

The preferred embodiment of the invention is not only capable of accounting for the effects of different hardware, firmware, software and configuration settings, but it can also predict the effects of just the hardware and firmware, just the software, or of a single configuration setting. The ability of the invention to measure and thus adjust empirically-derived predictions for these effects allows the optimization of the data communications network. By predicting the effects of changing any detailed aspect of the data communications network, a user can immediately visualize the effect of a new component or a setting change. This ability allows a user skilled in the art to design an optimal data communications network by continually making changes and observing the prediction changes.

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We now focus on the details for predicting values for network performance parameters based on knowledge of the 3-D site-specific environment as well as the specific components used in the network design.

The throughput and bandwidth of a network are calculated by the invention as functions of any or all of the following operational parameters which impact performance: distance between transmitter and receiver, physical environment specification, packet sizes, error and source coding schemes, packet overhead, modulation techniques, environment, interference, signal strength, number of users, and for wireless networks, the antenna pattern and type, multipath delay, number of multipath components, angle of arrival of multipath components, radio frequency bandwidth, protocol, coding scheme, and 3-D location. In order to predict the bandwidth and throughput of a network connection, the appropriate functions and constants may be calculated from the listed parameters and then predicted for each location and time desired.

For a wired network, throughput (T) or bandwidth (BW) may be derived from a vendor's specification sheet of a product or device, or may be measured in a special laboratory setting. Alternatively, T or BW may be calculated through analysis or simulation, or may be measured in the field using a number of known devices. These means may be used to determine the proper value for T or BW in a network prediction engine such as contemplated here. A formula for predicting the throughput and bandwidth for a wireless data communications channel is shown in equation 1.

$$T \text{ or } BW = C_1[Ad + Bd^2 + C] + \quad (1)$$

$$C_2[D(RSSI) + E(RSSI)^2 + F] + C_3 \sum_{i=1}^M (G_i P_i + K_i)$$

where T is throughput, BW is bandwidth, d is the distance between a transmitter and a receiver, RSSI is the received signal strength intensity, which is the power level of the signal at the receiver, either in absolute values or in logarithmic values. A, B, C, C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, D, E, F, K<sub>i</sub>, are constants or may represent linear or nonlinear functions of one or more physical or electrical parameters, such as physical environment type, packet size, modulation, modem type, or other parameters that relate the physical, electrical, or logical environment of the network. These constants or functions take on specific functional values depending upon if T or BW is being solved for. The value M may denote a particular number of multipath components from a particular transmitter, as determined by propagation analysis of the channel, or the term may denote a combination of important multipath components from a collection of transmitters, where the term "important" is based on antenna pattern, physical environment distances, and other wireless propagation factors which are well known to one skilled in the art and which are explained below. The values of G<sub>i</sub> and P<sub>i</sub> represent gains and power levels, respectively, for each of M different signal components, which may represent individual multipath components or gross signal components from one or more radiating sources, and K<sub>i</sub> represents a finite number of constants or functions for each value of i. Note that G<sub>i</sub>, P<sub>i</sub>, and the individual K<sub>i</sub> may be in logarithmic (e.g. dB) or absolute values. These constants or functions in the above equation may be dependent on distance (d) between transmitter and receiver where d may be the straight-line or actual reflected/diffracted distance of the main signal path between

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the serving transmitter and receiver, 3-D environment, time of observation or observation interval, noise power, packet sizes, coding scheme, number of users, modulation type, interference, and for wireless networks, may include path loss, multipath delay, number of multipath components, angular spread, strength and angle of arrival of received signals, modulation bandwidth, and other physical, electrical and logical settings of particular equipment in the network, and the constants or functions may be calculated analytically, predicted for an initial guess, or solved using best fit methods between measured and predicted performance of actual networks in a site specific environment.

It is important to note that multipath delay, and its effect on network performance prediction and design, may be considered in many ways, as contemplated by this invention and as shown in Equation (1). First, multipath may be considered individually, whereby each multipath component is considered to arrive from each transmitting device, and the methods for modeling multipath are well known and explained in the prior art, and in numerous research works by Rappaport, et. al. from Virginia Tech. Alternatively, gross multipath effects may be modeled as having a worst-case delay (e.g. propagation distance,  $d$ ) being approximated by the maximum, average, or median length of the specific building or 3-D environment in which the communication network is modeled. Alternatively, spatial considerations may be used by contemplating the antenna patterns of each transmitter or receiver, so that multipath which arrives only in the main beam of each wireless device is considered in the calculation of delay and in network performance in (1). Alternatively, only the strongest one or two or some finite number of transmitters may be considered for multipath propagation delays, whereby only a finite set of transmitters, such as those most closest to the receiver of interest, or those of a certain standard, frequency, or power setting, are considered to radiate multipath energy and produce RSSI values, and from that finite number of transmitters, only the strongest multipath, or the average, maximum, median, or largest few multipath components are considered in computation of delay. Alternatively, if only a finite number of transmitters are considered, methods described above, such as consideration of the physical environment to determine a gross multipath delay from each transmitter, or the use of a particular antenna pattern to determine most important multipath components, may be used to drive the model of multipath and its impact on network performance. Similar approaches may be used to model the received signal strength, RSSI in equation 1.

Note that the constants or functions of equation (1) may be assigned blindly for initial predictions, and then a specific network within the site-specific environment may be measured empirically so that a best-fit (using a minimum mean square error approach or some other well known method) may be used to assign values for the constants or functions in (1). Note that in (1), the distance ( $d$ ) may be based on true physical distance from the 3-D site specific model of the environment, or may actually represent a relative distance ratio, where the physical distance between two points is referenced to a convenient close-in free space reference distance, as is customary for propagation predictions, and is taught in (Rappaport, "Wireless Communications, Principle & Practice, Prentice-Hall, 1996).

Propagation delay for network data is predicted for wired networks, where components are interconnected by wire (either fiber or metal wire) by dividing the distance traveled by the propagation speed of the electrical, electromagnetic or optical signals in the device, which are used to transmit

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the data. For instance, data in a fiber optic cable travels at a speed  $2 \times 10^8$  meters per second due to dielectric properties of the cable, which affect the photons in a fiber optic cable that are used to transmit the data. Such photons move at the speed of light in glass, which is less than the free space propagation speed. Thus, if the cable is 200 meters long the transmission delay is equal to  $1 \times 10^{-6}$  seconds. By using the site-specific method of modeling the complete network within the present invention, it is possible for the user to simultaneously visualize the network as configured in the environment and see a display of delay and predicted or measured performance of delay within the cable within the 3-D environment. Additionally, using a tool tip mouse cursor or some other pointing means, or using a pull down menu, or by simply viewing the display device which the invention is implemented on, various network performance metrics, as well as stored data from the Bill of Materials and parameters of interest may be visualized or stored.

Predicting the propagation delay for a wireless portion of a data communications network is more difficult than wired networks due to the fact that multiple transmitter sources, such as access points in a Bluetooth network, IEEE 802.11b, or wireless ATM network may be transmitting simultaneously. Furthermore, as mentioned previously, multipath interference can create echoes that may or may not be equalized depending on the specific network equipment used at the wireless receiver or transmitter. However, the same calculation model used for wired networks may be used, with the additional consideration of multipath delay terms, and propagation losses or gains, due to specific multipath components, as shown in Equation (1). This additional consideration of multipath delay is needed to account for the fact that wireless data does not always travel in a straight line, and that physical objects can diffract, reflect, absorb, and scatter radio energy. Thus, to calculate the transmission delay of a wireless link in a data communications network, the distance between the transmitter and the receiver is divided by the propagation speed ( $3 \times 10^8$  meters per second) of a wireless communications link and then added to the multipath delay introduced by the indirect paths taken from transmitter to receiver as is shown in equation 2.

$$T_p = \frac{d}{3 \times 10^8 \text{ m/s}} + \tau_d \quad (2)$$

Where  $T_p$  is the propagation delay in seconds,  $d$  is the distance between the transmitter and the receiver in meters, and  $\tau_d$  is the multipath delay in seconds. Predicting the multipath delay is performed using well-known raytracing techniques or based on angle of arrival, or signal strength values, or by making estimated based on the physical model of the 3-D environment.

Transmission delay is directly calculated from the bandwidth of a connection using the number of bits transmitted. To calculate transmission delay, the number of transmitted bits is divided by the bandwidth. This calculation is identical for wired and wireless channels but must be performed separately for each network device. The formula is illustrated in equation 3.

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$$T_t = \frac{\# \text{ of bits}}{BW} \quad (3)$$

Where  $T_t$  is the transmission delay time in seconds, # of bits are the number of bits in the transmission or packet and BW is the bandwidth of the network link in bits per seconds.

Processing delay must be calculated for each device separately within a network. Processing delay is the time required for a network device to process, store, and forward the data bits that are applied to a network device. Alternatively, processing delay may be the time required for a source to produce a meaningful data stream once it is instructed to do so. Processing delay is known to be zero for devices that do not perform any processing, such as passive network components like cables, antennas, or splitters. Processing time may depend on the packet size, protocol type, operating system, vendor, firmware, hardware, and software versions or configurations, and the type of device and the current computing load on the device. To predict the processing delay of any device it is necessary use a model that accounts for all of these effects. These models may be measured in the field, measured in a test facility, obtained from vendors, or derived from analysis or simulation.

Queuing delay is only applicable to devices that transmit data from multiple users or multiple connections. The queuing delay of a device is the amount of time a particular packet must wait for other traffic to be transmitted. It is difficult to predict the queuing delay of a particular connection because it depends on the amount of traffic handled by a particular device. For this reason, queuing delays can be predicted using a statistical random variable based on the expected performance of the device and/or the expected traffic load. Alternatively, average, median, best or worst case, or some other linear or nonlinear weighing of queuing delay times as defined by the device specifications, or as measured, simulated, or computed by analysis, may be used to calculate a predicted queuing delay time.

Packet latency, round-trip times and handoff delay times are all based on propagation, transmission, processing, and queuing delay times. To accurately predict packet latency and round trip time, the propagation, transmission, processing and queuing delay times must be summed for all network devices in a particular network link and adjusted using the particular traffic type, packet size, and protocol type. For instance, packet latency is the time required for a packet to travel from transmitter to receiver. To predict packet latency for a particular link the propagation, transmission, processing and queuing delay times must be calculated using the specific network connection, traffic type, and packet size for the one-way transmission of a packet.

Round trip times are calculated similarly, except for the transmission and reception of a packet and the return of the acknowledging packet. Thus, to predict the round trip time, the invention takes into account the original packet size and the size of the acknowledging packet as well as the effects of the specific network connection, protocol and traffic type on the propagation, transmission, processing and queuing delays.

Handoff delay times are based on the propagation, transmission, processing and queuing delays involved in two separate wireless access points coordinating the change of control of a wireless device from one access point to another. These delays result because the two access points must transmit data back and forth to successfully perform a

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handoff. Thus, the prediction of handoff delay time is similar to the prediction of the packet latency time between the two access points. To predict the handoff delay time, the invention calculates the propagation, transmission, processing and queuing delays for the link between the two access points. The invention then adjusts for the specific number of transmissions required and the size of the data, which must be sent to successfully perform a handoff.

When predicting bit error rates, the invention considers wired and wireless error rates. Wireless networks operate in much more hostile electrical environments than their wired counterparts and their interconnections are significantly more difficult to model and, until this invention, practical networks have not successfully been modeled using specific, accurate physical and electrical models of multiple transmitters, multiple interferers, noise sources, and network components within a 3-D site-specific environment. This invention uses 3-D site specific representations of the environment for specific network implementations that are able to consider both wired and wireless networks, and considers physical locations, electrical specifications and attributes of all radiating sources and their antenna systems in a real-world 3-D environmental model. Wireless networks are prone to data errors much more so than wired channels, due to the impact of multipath propagation, multiple transmitters, and noise, as described previously. The fact that radio propagation and noise is more random than for fixed wired networks must be considered for practical design, and is modeled in this invention. For wired channels, bit error rates are simply a measure of the electrical, optical and electromagnetic parameters of a connection and are predicted using a statistical random variable, such as a Gaussian or Poisson random distribution, or other sensible distribution or algorithm known now or in the future, and this random variable is overlaid about the average, median, or typical performance of the network component or network subsystem. The network device or subsystem may include a single wireless node, such as a router or switch, or a complete interconnection of various routers, hubs, switches, wireless access points, and wireless client/server devices that communicate with the network. The network may be wired, wireless, or a combination thereof.

Many performance metrics of a device or a network subsystem, such as Frame Error Rate, Bit Error Rate, or Packet Error Rate, as well as other performance parameters such as throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time may be either derived from a specification of the equipment, may be calculated analytically within the invention or inputted into the invention, or may be measured a priori in advance to using the invention. That is, specific parameters of operation, known as operating parameters or equipment parameters, such as those listed previously, can be either measured or predicted through equipment specifications provided by vendors. Alternatively, they may be measured in-situ by a user or research facility, for proper modeling and input into the invention. Alternatively, they may be calculated based on some known analytical model that contemplates interconnection of devices so that a performance model and operating parameters may be computed. The statistical random variable to model network performance within the invention can be dependant on the electrical, optical and electromagnetic characteristics of each device such as voltage levels, power levels, impedance,



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and operating frequencies, or can be generated using a typical observed (measured) value for each network device. For instance, copper wire can be modeled as having a bit error rate of 1 error in  $10^6$  or  $10^7$  bits transmitted. Once measured and characterized a single initial time, a single component or a string of components within a network may be modeled repeatedly by the invention, so that network performance models.

Wireless performance parameters, however, are dependant on many more factors than wired bit error rates. For this reason, the invention predicts wireless bit error rates based on the environment, distance between transmitter and receiver, number and types of partitions obstructing the transmission, time, 3-D position, packet size, protocol type, modulation, radio frequency, radio frequency bandwidth, encoding method, error correction coding technique, multipath signal strengths and angle of arrival, and multipath delay. As a result, the calculation of the predicted bit error rate is performed using constants or functions to convert from previously measured or known channel and network equipment performance metrics to an expected bit error rate. A formulation for predicting the bit error rate, frame error rate or packet error rate directly for a data communications channel is shown in equation 4, and is identical to equation 1.

$$BER, PER, \text{ or } FER = C_1(Ad + Bd^2 + C) + \quad (4)$$

$$C_2[D(RSSI) + E(RSSI)^2 + F] + C_3 \sum_{i=1}^M (G_i P_i + K_i)$$

where BER is bit error rate, FER is the frame error rate, PER is the packet error rate, d is the distance between a transmitter and a receiver. RSSI is the received signal strength intensity, which is the power level of the signal at the receiver. A, B, C, C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, D, E, F, K<sub>i</sub>, are constants or linear or non linear functions with different values depending on which of BER, FER, and PER is being calculated. The value M may denote particular number of multipath components from a particular transmitter, or may denote a combination of important multipath components from a collection of transmitters, where the term "important" is based on antenna pattern, physical environment distances, and other wireless propagation factors which are well known to one skilled in the art and which are explained within this disclosure. The each of M values of G<sub>i</sub> and P<sub>i</sub> represent gains and power levels, respectively, of different signal components, which may represent individual multipath components or gross signal components from one or more radiating sources, and may be in logarithmic or linear values of power. The variables G<sub>i</sub> and P<sub>i</sub> and each one of the M number of K<sub>i</sub> values may be in logarithmic (e.g. dB) or absolute values. These constants in the above equation are dependant on distance (d) between transmitter and receiver where d may be the straight-line or actual reflected/diffracted distance of the main signal path between the serving transmitter and receiver. As explained in the text surrounding equation (1), distance may be straight-line distance, or may be modeled from the gross characteristics of the environment, such as the maximum, average, or median length of the 3-D environment. As with equation (1), equation (4) may consider the distance d as the actual physical distance, or as a relative distance referenced to a close-in reference.

Frame error rates, packet error rates and packet drop rates can all be calculated from bit error rates or predicted directly

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using the same method as for a bit error rate as described above or as modeled in equation 4. To perform these calculations the invention uses information stored in the site-specific Bill of Materials about the packet size, frame size and the protocol in use, and uses a site-specific propagation and interference modeling technique, such as that utilized in the SitePlanner product by Wireless Valley Communications, Inc.

In wireless networks, modeling the combined effects of all the various sources of errors is extremely difficult. Not only does modulation and specific error and source coding techniques impact the wireless network performance, but so does the impact of antennas, multipath, noise, voice over IP or wireless ATM concatenation methods, modem design of particular wireless modem makers, and the specific RF distribution system used to connect wired and wireless devices. The ability to model such varied effects can be done by allowing field measurement of specific in-situ network performance as explained earlier. By conducting a walk-through or a drive test whereby a mobile receiver is operated and network performance parameters are measured within the site-specific environment, it is then possible to determine best fits for particular modem manufacturers, applying concepts described in equation 1.

Bandwidth delay products can be calculated by the invention directly using information about any or all of the environment, three dimensional position, protocol type, multipath delay, packet sizes, radio frequency, radio frequency bandwidth, coding, number, strength and angle of arrival of multipath components, signal strength, transmission, propagation, processing and queuing delay, bit error rate, packet error rate, and frame error rates. Alternatively the invention can calculate the bandwidth delay product indirectly using previously predicted values. A bandwidth delay product is calculated by multiplying the bandwidth of a certain network device by the total delay introduced by that device. Thus, the formula is illustrated here in equation 5:

$$BWD = \frac{BW}{T_{net}} \quad (5)$$

Where BWD is the bandwidth delay product, BW is the bandwidth and T<sub>net</sub> is the total delay introduced.

The invention uses statistical models of the consistency of data communications network hardware to predict packet jitter and quality of service (QoS). Both of these performance criterions are measures of the reliability of a network to provide consistent data arrival times. Thus, to calculate the QoS or jitter of a connection, the invention uses formulas which include any or all of the environment, three dimensional position, protocol type, multipath delay, packet sizes, radio frequency, radio frequency bandwidth, coding, number, strength and angle of arrival of multipath components, signal strength, transmission, propagation, processing and queuing delay, bit error rate, packet error rate, frame error rate, throughput, bandwidth, and bandwidth delay product. The formulas include constants or functions, which relate the above variables in general to the variation in the arrival time of data and in specific to the QoS and packet jitter of a connection. The present embodiment of the current invention uses equations (1) or (4) to determine QoS and packet jitter for a data communications network.

The preferred embodiment of the invention predictions consider the effects of not just the site specific, floor plan, building layout, terrain characteristics and RF characteris-

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tics, but also the effects of the particular network hardware, firmware and software in the network. The invention allows the network to be modeled down to the settings and locations of the individual data communications devices, using the Bill of Materials discussed earlier. The prediction of network performance statistics takes these settings into account. This means that different transport level protocols (such as TCP or UDP), different protocol settings (such as packet and buffer sizes), the data bandwidth (in bits per second), physical layer transmission methods including modulation techniques (such as QPSK or FHSS), coding schemes (such as CCK or trellis codes), transport media (such as copper, fiber optic cable or wireless connections) and specific frequency bands are taken into account by the invention. These aspects are in addition to the consideration of the location and wireless specific criteria, which includes transmitter-receiver distance (T-R distance), the propagation environment, interference, path loss, number of users sharing the RF resources, multipath delay, the number of multipath components and their strengths and angle of arrival, the ratio of coherent to incoherent power, and the RF bandwidth (in Hz). All of these variables may produce results which may be mapped into the form of equation (1) or (4).

The predictions of the preferred form of the invention consider the characteristics of the data communications network users. Information such as the type of data communications traffic the users offer to the network, the number of users, and the usage patterns over time, are stored in a location specific manner in the invention. That is, points can be placed which represent individual users and the traffic offered by that user or areas in which the characteristics of a group or pool of users can be assigned. The invention takes these points and areas of user traffic into account when making predictions of network performance criterions. This means that if large numbers of users are found in an area covered by access points that are able to adapt to heavy usage, the invention is able to accurately predict the performance of these (or any other) conditions. This is only possible because of the accurate, location specific model of the data communication network. Additionally, since the preferred form of the invention tracks usage patterns of users over time, the resulting measurements may be used by a server processor to form table look-up values for the constants or functions of Equations (1) or (4). Different values of constants or functions for Equations (1) or (4) may be found to predict the performance of the network at different times of day. This is an important aspect of a data communication network prediction model because real networks have peak usage times and lulls in which usage is lower. By tracking the usage of a data communications network over time, the preferred form of the invention can determine if the network will have difficulties at certain times.

In a communications network, the capacity is always a scaled version of the theoretical maximum possible capacity, and the impact of various users, and their propagation characteristics, message sizes, as well as the network characteristics, all combine to bound or limit the capacity that an individual user sees on a network. Consider a network that has, as a bottleneck, a particular component or device which has a maximum rating of  $T_{max}$  bits per second. This component bounds the maximum possible throughput of the network. Consider that capacity represents the capacity or throughput of a device or network (defined as  $T$  or Capacity), where  $T(x,y,z,t) = T_{max}[y]$ , where  $y$  is a scaling factor that fuses many different, complicated physical, electrical, and logical conditions into a simple value that ranges between 0 and 1. When gamma is 0, there is no capacity.

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When gamma is 1, there is maximum capacity. Note that  $T$  is a function of 3-D positioning in the network, as well as a function of time. For a particular user, the goal of a network predictive model is to predict the capacity, as a function of 3-D position and as a function of time. Thus,  $T[x,y,z,t]$  will range between 0 and  $T_{max}$ .

The load put on to a data communications network impacts the capacity of an individual user. The number of users and the usage patterns of each user affect the capacity of each user in a data communications network. The preferred embodiment of the invention allows a network designer to see the effects of network loading on the important network statistics, by measuring the instantaneous traffic conditions with the measurement agents as described above. It is possible to determine in-situ capacity measurements through other means, such as observation from network equipment or reporting mechanisms built into hardware or software products. By forming a table look-up of the specific capacity results, as a function of 3-D site-specific location, as well as the time of day, the invention builds a measurement-based predictive model for capacity. These measurements may be used to form a model of capacity, as now presented.

The invention contemplates the fact that the scaling factor on capacity (or throughput), is a function of the instantaneous number of users of the network, the maximum number of simultaneous users of the network, the average and maximum packet size used by users of the network, and for many other factors that are modem or network or vendor or protocol specific. Also, in the case of a wireless network, the multipath propagation effects, the propagation distances between the user and the wireless access points, and the received signal levels are factors that limit capacity. In addition, constants or functions that fuse the impact of modulation, equalizations, impulse noise, and other factors, are used in the invention.

Thus, capacity or throughput of a network is modeled by

$$\text{Capacity} = C_1 [Ad + Bd^2 + C] + \quad (6)$$

$$C_2 [D(RSS) + E(RSS)^2 + F] + C_3 \sum_{i=1}^M (G_i P_i + K_i)$$

where the constants or functions of (6) take on similar properties as described for equations (1) and (4). Furthermore, the entire equation (6) may be scaled by  $K/U_{max}$ , where  $K$  is the instantaneous number of users on the network, and  $U_{max}$  denotes the maximum number of simultaneous users possible.

Handoff delay times are potential problems in wireless data communication networks. A handoff occurs in wireless data networks when a user moves out of range of one access point and into range of another access point. In this situation, the first access point must pass the responsibility of delivering data to the wireless user to the second access point. If the two access points are too far apart, there will not be enough time for a wireless data network user to be handed off from one access point to another and file transfers can fail. The invention predicts where handoffs will occur and the possibility of handoff failures due to incompatible network settings at two different access points by using site-specific time dependent measurements, and fitting them into a form of equation (1), (4) or (6). Then, a table look up method is used to determine prediction models for handoff times as a function of spatial positioning and time of day.

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The concept of optimization is a key aspect of the invention. The preferred invention is highly effective at allowing one skilled in the art to quickly improve the performance of an existing data communications network by comparing measured performance parameters with predicted values that are derived and stored in the invention. The process of using measurements to improve predictions is called optimization and is illustrated in FIG. 6, FIG. 7, and FIG. 8. The method for optimizing a network using just measurements is shown in FIG. 6, just predictions in FIG. 7, and a combination of measurements and predictions in FIG. 8. The process of optimizing a data communications network is accomplished by comparing, through numerical, visual, or some other means, the predictions and measurements of performance criteria such as throughput, bandwidth, quality of service, bit error rate, packet error rate, frame error rate, dropped packet rate, packet latency, round trip time, propagation delay, transmission delay, processing delay, queuing delay, network capacity, packet jitter, bandwidth delay product and handoff delay time for various site-specific locations and particular times of day. By changing the hardware used in the network, or changing the locations of hardware or the configuration of that hardware, firmware, or software which controls each device within the network, one skilled in the art can improve the performance of the network. These performance improvements can be implemented and viewed by repeating predictions of the performance criteria after site-specific equipment changes to the network have been made in the 3-D model of the network. Continuing this process allows one skilled in the art to optimize the performance of a network to achieve an efficient data communications network.

Using this information, the preferred embodiment of the invention can make recommendations for the areas of the network to upgrade or reconfigure. The invention can also use SNMP protocol communications or other protocols to actually implement these changes. That is, a network designer could identify problems in a data communications network through prediction, whereby the prediction of performance criteria of the data communications network is calculated using known measurement data and the configuration and expected performance of all data communications hardware in the data communications network. The predicted performance criterion is stored and displayed visually and numerically in a location specific, three-dimensional model of the environment. Then, the designer can use the invention to identify a solution to the problems that are apparent by viewing the prediction results, either by following the inventions recommendations for changes or making the designers own change. After simulating the predicted outcome, the network designer can then direct the invention to update all the relevant settings of the equipment with the changes the designer has just used in a prediction. The designer could then use the tool to measure the results of these changes using the measurement features of the invention.

While this invention has been described in terms of its preferred embodiments, those skilled in the art will recognize that the invention can be practiced with considerable variation within the scope of the appended claims.

What is claimed is:

1. A method for analyzing and adjusting a wireless communications network, comprising the steps of:  
generating or using, with a computer or server, a computerized model of a wireless communications network within a physical space in which said wireless communications network is deployed, said computerized

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model providing a site specific representation of one or more of a floor plan, building layout, terrain characteristics, or RF characteristics, said computerized model identifying locations within said physical space of one or more components used in said wireless communications network, said computerized model having modeled attributes for at least one each of said one or more components;

receiving, at said computer or server, measurement data from one or more measurement collectors or agents located in said physical space, said one or more measurement collectors or agents being the same or different from one or more of said one or more components used in said wireless communications network;

predicting, at said computer or server, one or more performance metrics for said wireless communications network, wherein predictions are made based on said modeled attributes for said at least one of said one or more components, and said measurement data from said one or more measurement collectors or agents; and changing settings or configurations of at least one component of said wireless communications network based on instructions sent from said computer or server.

2. The method of claim 1 wherein said site specific representation is three dimensional.

3. The method of claim 1 wherein said data collection measurement collectors or agents are portable or fixed.

4. The method of claim 1 further comprising the step of affixing said measurement collectors or agents permanently within said physical space.

5. The method of claim 1 wherein said performance metric predicted in said predicting step is selected from the group consisting of throughput, error rates, packet latency, packet jitter, symbol jitter, quality of service, security, coverage area, bandwidth, bit error rate, packet error rate, frame error rate, dropped packet rate, queuing delay, round trip time, capacity, signal level, interference level, bandwidth delay product, handoff delay time, signal-to-interface ratio, signal-to-noise ratio, physical equipment price, and cost information.

6. The method of claim 1 wherein said measurement data received in said receiving step obtained manually.

7. The method of claim 1 wherein said measurement data received in said receiving step obtained autonomously.

8. The method of claim 1 further comprising the step of storing said measurement data.

9. The method of claim 1 further comprising the step of updating said computerized model.

10. The method of claim 9 wherein said step of updating includes the steps of:

specifying components from a plurality of different modeled components which are to be used in said communications network, said modeled components including descriptions and attributes of a specific component; and specifying locations within said physical space for a plurality of different components in said computerized model.

11. The method of claim 10 wherein said step of updating further includes the step of specifying an orientation for at least one component specified in said first specifying step at said location specified in said second specifying step.

12. The method of claim 1 wherein said computerized model identifies orientations of said components at said locations within said physical space and said predicting step utilizes said orientations.

13. The method of claim 1 wherein said computerized model includes one or more objects which create noise or



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interference, said noise or interference being an attribute of said one or more objects which are factored in said predicting step.

14. The method of claim 1 wherein said one or more performance metrics predicted in said predicting step are predicted in a forward direction in said wireless communication network.

15. The method of claim 1 wherein said one or more performance metrics predicted in said predicting step are predicted in a reverse direction in said wireless communication network.

16. The method of claim 1 further comprising the step of specifying data transfer protocol, and wherein said predicting step uses a specified data transfer protocol as a factor in predicting said one or more performance metrics.

17. The method of claim 1 further comprising the step of specifying a network loading for said wireless communications network, and wherein said predicting step uses a specified network loading in predicting said one or more performance metrics.

18. The method of claim 1 further comprising the step of storing or visualizing data representing comparisons of measurements with predictions.

19. The method of claim 1 further comprising the step of storing or visualizing data representing either or both logical connections of network components or physical locations of network components.

20. A system or apparatus for analyzing and adjusting a wireless communications network, comprising:

a computer or server for generating or using a computerized model of a wireless communications network positioned within a physical space, said computerized model providing a site specific representation of one or more of a floor plan, building layout, terrain characteristics, or RF characteristics, said computerized model identifying locations within said physical space of one or more components used in said wireless communications network, said computerized model having modeled attributes for at least one of said one or more components;

one or more measurement collectors or agents operating or operational within said physical space which send measurement data to said computer or server, said computer or server predicting one or more performance metrics for said wireless communications network based on said measurement data and said modeled attributes for said at least one of said one or more components, and said computer or server can send instructions to one or more components of said wireless communications network which cause settings or configurations of at least one component to be changed.

21. The system or apparatus of claim 20 wherein said site specific representation is three dimensional.

22. The system or apparatus of claim 20 wherein said measurement collectors or agents are portable or fixed.

23. The system or apparatus of claim 20 wherein said measurement collectors or agents are permanently affixed at within said physical space.

24. The system or apparatus of claim 20 wherein said performance metric predicted by said computer or server is selected from the group consisting of throughput, error rates, packet latency, packet jitter, symbol jitter, quality of service, security, coverage area, bandwidth, bit error rate, packet error rate, frame error rate, dropped packet rate, queuing delay, round trip time, capacity, signal level, interference

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level, bandwidth delay product, handoff delay time, signal-to-interface ratio, signal-to-noise ratio, physical equipment price, cost information.

25. The system or apparatus of claim 20 further comprising a storage device for storing said measurement data.

26. The system or apparatus of claim 20 wherein said computerized model is stored on at least one server, wherein said at least one server is the same or different from said computer or server.

27. The system or apparatus of claim 26 wherein said computerized model is stored on a plurality of servers, and said plurality of servers can communicate with each other.

28. The system or apparatus of claim 27 wherein said plurality of servers have a hierarchical relationship to one another.

29. The system or apparatus of claim 26 further comprising at least one portable client device, said at least one portable client device can communicate with said at least one server.

30. The system or apparatus of claim 28 wherein said system includes a plurality of portable client devices.

31. The system or apparatus of claim 20 further comprising a storage medium or display for, respectively, storing or visualizing data representing comparisons of measurements with predictions.

32. The system or apparatus of claim 20 further comprising a storage medium or display for, respectively, storing or visualizing either or both logical connections of network components or physical locations of network components.

33. A method for analyzing and adjusting a wireless communications network, comprising the steps of:

generating or using, with a computer or server, a computerized model of a wireless communications network within a physical space in which said communications network is deployed, said computerized model providing a site specific representation of one or more of a floor plan, building model, terrain characteristics, or RF characteristics, said computerized model identifying locations within said physical space of one or more components used in said wireless communications network, said computerized model having modeled attributes for at least one of said one or more components;

downloading or inputting files of measurement data to said computer or server, where said measurement data is obtained from said physical space or from said wireless communications network;

predicting or providing a one or more performance metrics for said wireless communications network based on said measurement data and said modeled attributes for said at least one of said one or more components; and

changing settings or configurations of at least one component of said wireless communications network based on instructions sent from said computer or server.

34. The method of claim 33 wherein said measurement data is obtained from measurement collectors or agents that are either portable or fixed.

35. The method of claim 33 further comprising the step of storing or visualizing data representing comparisons of measurements with predictions.

36. The method of claim 33 further comprising the step of storing or visualizing data representing either or both logical connections of network components or physical locations of network components.

37. A site specific method for analyzing and adjusting a communications network, comprising the steps of:

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generating or using, with a computer or server, a computerized model of a communications network positioned within a physical space, said computerized model providing a site specific representation of one or more of a floor plan, building layout, terrain characteristics or RF characteristics, said computerized model identifying locations within said physical space of one or more components used in said communications network, said computerized model having modeled attributes for at least one of said one or more components

receiving, at said computer or server, measurement data from one or more measurement collectors or agents located in said physical space, said one or more measurement collectors or agents being the same or different from one or more of said one or more components used in said communications network;

predicting, using said computer or server, one or more performance metrics for said communications network, wherein predictions are made based on said measurement data and said modeled attributes for at least one of said one or more components;

changing settings or configurations of at least one component of said communications network based on instructions sent from said computer or server.

38. The method of claim 37 wherein said site specific representation is three dimensional.

39. The method of claim 37 wherein said measurement collectors or agents portable or fixed.

40. The method of claim 37 further comprising the step of affixing said measurement collectors or agents permanently within said physical space.

41. The method of claim 37 wherein said one or more performance metrics predicted in said predicting step are selected from the group consisting of one or more performance metrics are selected from radio signal strength intensity, connectivity, network throughput, bit error rate, frame error rate, signal-to-interference ratio, signal-to-noise ratio, frame resolution per second, traffic, capacity, signal strength, throughput, error rates, packet latency, packet jitter, symbol jitter, quality of service, security, coverage area, bandwidth, server identification parameters, transmitter identification parameters, best server locations, transmitter location parameters, billing information, network performance parameters, C/I, C/N, body loss, height above floor, height above ground, noise figure, secure coverage locations, propagation loss factors, angle of arrival, multipath components, multipath parameters, antenna gains, noise level reflectivity, surface roughness, path loss models, attenuation factors, throughput performance metrics, packet error rate, round trip time, dropped packet rate, queuing delay, signal level, interference level, quality of service, bandwidth delay product, handoff delay time, signal loss, data loss, number of users serviced, user density, locations of adequate coverage, handoff locations or zones, locations of adequate throughput,  $E_b/N_0$ , system performance parameters, equipment price, maintenance and cost information, user class or subclass, user type, position location, all in either absolute or relative terms.

42. The method of claim 37 wherein said measurement data received in said receiving step is obtained manually.

43. The method of claim 37 wherein said measurement data received in said receiving step is obtained autonomously.

44. The method of claim 37 further comprising the step of storing said measurement data.

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45. The method of claim 37 further comprising the step of updating said computerized model.

46. The method of claim 45 wherein said step of updating includes the steps of:

specifying components from a plurality of different modeled components which are to be used in said communications network, said modeled components including descriptions and attributes of a specific component; and specifying locations within said space for a plurality of different components in said computerized model.

47. The method of claim 46 wherein said step of updating further includes the step of specifying an orientation for at least one component specified in said specifying components step at said location specified in said specifying locations step.

48. The method of claim 37 wherein said computerized model identifies orientations of one or more of said one or more components at said locations within said physical space and said predicting step utilizes said orientations.

49. The method of claim 37 wherein said computerized model includes one or more objects which create noise or interference, said noise or interference being an attribute of said one or more objects which are factored in said predicting step.

50. The method of claim 37 wherein said one or more performance metrics predicted in said predicting step are predicted in a forward direction in said communication network.

51. The method of claim 37 wherein said one or more performance metrics predicted in said predicting step are predicted in a reverse direction in said communication network.

52. The method of claim 37 further comprising the step of specifying data transfer protocol, and wherein said predicting step uses a specified data transfer protocol as a factor in predicting said performance metric.

53. The method of claim 37 further comprising the step of specifying a network loading for said communications network, and wherein said predicting step uses a specified network loading in predicting said one or more performance metrics.

54. The method of claim 37 further comprising the step of storing or visualizing data representing comparisons of measurements with predictions.

55. The method of claim 37 further comprising the step of storing or visualizing data representing either or both logical connections of network components or physical locations of network components.

56. A site specific system or apparatus for analyzing and adjusting a communications network, comprising:

a computer or server for generating or using a computerized model of a communications network positioned within a physical space, said computerized model providing a site specific representation of one or more of a floor plan, building layout, terrain characteristics or RF characteristics, said computerized model identifying locations within said physical space of one or more components used in said communications network, said computerized model having modeled attributes for at least one of said one or more components;

one or more measurement collectors or agents positioned within said physical space which obtain and send measurement data to said computer or server, said computer or server predicting one or more performance metrics for said communications network based on said measurement data and said modeled attributes for said at least one of said one or more components, and said

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computer or server can send instructions to one or more components of said communications network which cause settings or configurations of at least one component to be changed.

57. The system or apparatus of claim 56 wherein said site specific representation is three dimensional.

58. The system or apparatus of claim 56 wherein said measurement collectors or agents are portable or fixed.

59. The system or apparatus of claim 56 wherein said measurement collectors or agents are permanently affixed at locations within said physical space.

60. The system or apparatus of claim 56 wherein said one or more performance metrics selected from the group consisting of one or more performance metrics are selected from radio signal strength intensity, connectivity, network throughput, bit error rate, frame error rate, signal-to-interference ratio, signal-to-noise ratio, frame resolution per second, traffic, capacity, signal strength, throughput, error rates, packet latency, packet jitter, symbol jitter, quality of service, security, coverage area, bandwidth, server identification parameters, transmitter identification parameters, best server locations, transmitter location parameters, billing information, network performance parameters, C/I, C/N, body loss, height above floor, height above ground, noise figure, secure coverage locations, propagation loss factors, angle of arrival, multipath components, multipath parameters, antenna gains, noise level reflectivity, surface roughness, path loss models, attenuation factors, throughput performance metrics, packet error rate, round trip time, dropped packet rate, queuing delay, signal level, interference level, quality of service, bandwidth delay product, handoff delay time, signal loss, data loss, number of users serviced, user

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density, locations of adequate coverage, handoff locations or zones, locations of adequate throughput,  $E_b/I_0$ , system performance parameters, equipment price, maintenance and cost information, user class or subclass, user type, position location, all in either absolute or relative terms.

61. The system or apparatus of claim 56 further comprising a storage device for storing said measurement data.

62. The system or apparatus of claim 56 wherein said computerized model is stored on at least one server which may be the same or different from said computer or server.

63. The system or apparatus of claim 62 wherein said computerized model is stored on a plurality of servers, wherein said plurality of servers can communicate with each other.

64. The system or apparatus of claim 63 wherein said plurality of servers have a hierarchical relationship to one another.

65. The system or apparatus of claim 62 further comprising at least one portable client device that can communicate with said at least one server.

66. The system or apparatus of claim 64 wherein said system includes a plurality of portable client devices.

67. The system or apparatus of claim 56 further comprising a storage medium or display for, respectively, storing or visualizing data representing comparisons of measurements with predictions.

68. The system or apparatus of claim 56 further comprising a storage medium or display for, respectively, storing or visualizing either or both logical connections of network components or physical locations of network components.

\* \* \* \* \*



UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 6,973,622 B1  
APPLICATION NO. : 09/668145  
DATED : December 6, 2005  
INVENTOR(S) : Rappaport et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 30, line 7 change "each of" to --of--

Column 30, line 38 change "interface" to --interference--

Column 30, line 42 insert "is" after "step"

Column 30, line 44 insert "is" after "step"

Column 32, line 2 change "interface" to --interference--

Column 32, line 21 insert "or apparatus" after "system".


Column 32, line 48 delete "a"

Column 33, lines 36, 37 delete "one or more performance metrics are selected from"

Column 35, line 14 delete "one or more performance metrics are selected from"

Signed and Sealed this

Fifth day of September, 2006



JON W. DUDAS  
*Director of the United States Patent and Trademark Office*

The JS-44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

SYMBOL TECHNOLOGIES, INC. and WIRELESS VALLEY COMMUNICATIONS, INC.

(b) County of Residence of First Listed Plaintiff Suffolk, New York  
(EXCEPT IN U.S. PLAINTIFF CASES)

## ARUBA NETWORKS, INC.

County of Residence of First Listed Defendant Santa Clara  
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.

(c) Attorney's (Firm Name, Address, and Telephone Number)

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Attorneys (If Known)

**II. BASIS OF JURISDICTION** (Place an "X" in One Box Only)

- |                            |                              |                                       |   |
|----------------------------|------------------------------|---------------------------------------|---|
| <input type="checkbox"/> 1 | U.S. Government<br>Plaintiff | <input checked="" type="checkbox"/> 3 | Federal Question<br>(U.S. Government Not a Party)             |
| <input type="checkbox"/> 2 | U.S. Government<br>Defendant | <input type="checkbox"/> 4            | Diversity<br>(Indicate Citizenship of Parties<br>in Item III) |

**III. CITIZENSHIP OF PRINCIPAL PARTIES** (Place an "X" in One Box for Plaintiff and One Box for Defendant)

- |   | FTF                        | DEF                        |   | FTF                        | DEF                        |
|---|----------------------------|----------------------------|---|----------------------------|----------------------------|
| Citizen of This State                   | <input type="checkbox"/> 1 | <input type="checkbox"/> 1 | Incorporated or Principal Place of Business In This State     | <input type="checkbox"/> 4 | <input type="checkbox"/> 4 |
| Citizen of Another State                | <input type="checkbox"/> 2 | <input type="checkbox"/> 2 | Incorporated and Principal Place of Business In Another State | <input type="checkbox"/> 5 | <input type="checkbox"/> 5 |
| Citizen or Subject of a Foreign Country | <input type="checkbox"/> 3 | <input type="checkbox"/> 3 | Foreign Nation  | <input type="checkbox"/> 6 | <input type="checkbox"/> 6 |

## IV. NATURE OF SUIT (Place an "X" in One Box Only)

CONTRACT		TORTS		FORFEITURE/PENALTY		BANKRUPTCY		OTHER STATUTES	
<input type="checkbox"/> 110 Insurance	<b>PERSONAL INJURY</b>	<input type="checkbox"/> 310 Airplane	<b>PERSONAL INJURY</b>	<input type="checkbox"/> 610 Agriculture	<input type="checkbox"/> 422 Appeal 28 USC 158	<input type="checkbox"/> 400 State Reapportionment	<input type="checkbox"/> 110 Antitrust	<input type="checkbox"/> 130 Miller Act	<input type="checkbox"/> 430 Banks and Banking
<input type="checkbox"/> 140 Negotiable Instrument	<input type="checkbox"/> 315 Airplane Product Liability	<input type="checkbox"/> 362 Personal Injury — Med. Malpractice	<input type="checkbox"/> 620 Other Food & Drug	<input type="checkbox"/> 423 Withdrawal	<input type="checkbox"/> 28 USC 157	<input type="checkbox"/> 450 Commerce/ICC Rates/etc.	<input type="checkbox"/> 460 Deportation	<input type="checkbox"/> 150 Recovery of Overpayment & Enforcement of Judgment	<input type="checkbox"/> 470 Racketeer Influenced and Corrupt Organizations
<input type="checkbox"/> 151 Medicare Act	<input type="checkbox"/> 320 Assault, Libel & Slander	<input type="checkbox"/> 365 Personal Injury — Product Liability	<input type="checkbox"/> 630 Liquor Laws	<input type="checkbox"/> 440 R.R. & Truck	<b>PROPERTY RIGHTS</b>	<input type="checkbox"/> 820 Copyrights	<input type="checkbox"/> 810 Selective Service	<input type="checkbox"/> 152 Recovery of Defaulted Student Loans (Encl. Veterans)	<input type="checkbox"/> 830 Securities/Commodities/Exchange
<input type="checkbox"/> 153 Recovery of Overpayment of Veteran's Benefits	<input type="checkbox"/> 330 Federal Employers' Liability	<input type="checkbox"/> 368 Asbestos Personal Injury Product Liability	<input type="checkbox"/> 640 R.R. & Truck	<input type="checkbox"/> 650 Airline Regs.	<input type="checkbox"/> 830 Patent	<input type="checkbox"/> 840 Trademark	<input type="checkbox"/> 875 Customs Challenge 12 USC 3410	<input type="checkbox"/> 155 Contract Product Liability	<input type="checkbox"/> 891 Agricultural Acts
<input type="checkbox"/> 160 Stockholders' Suits	<input type="checkbox"/> 340 Marine	<b>PERSONAL PROPERTY</b>	<input type="checkbox"/> 650 Occupational Safety/Health	<input type="checkbox"/> 690 Other	<b>LABOR</b>	<b>SOCIAL SECURITY</b>	<input type="checkbox"/> 892 Economic Stabilization Act	<input type="checkbox"/> 190 Other Contract	<input type="checkbox"/> 893 Environmental Matters
<input type="checkbox"/> 195 Contract Product Liability	<input type="checkbox"/> 345 Marine Product Liability	<input type="checkbox"/> 370 Other Fraud	<input type="checkbox"/> 710 Fair Labor Standards Act	<input type="checkbox"/> 720 Labor/Mgmt. Relations	<input type="checkbox"/> 861 HIA (1395f)	<input type="checkbox"/> 862 Black Lung (923)	<input type="checkbox"/> 894 Energy Allocation Act	<input type="checkbox"/> 350 Motor Vehicle	<input type="checkbox"/> 895 Freedom of Information Act
	<input type="checkbox"/> 350 Motor Vehicle	<input type="checkbox"/> 371 Truth in Lending	<input type="checkbox"/> 730 Labor/Mgmt. Reporting & Disclosure Act	<input type="checkbox"/> 740 Railway Labor Act	<input type="checkbox"/> 863 DIWC/DIWW (405(g))	<input type="checkbox"/> 864 SSD Title XVI	<input type="checkbox"/> 865 RSI (405(g))	<input type="checkbox"/> 355 Motor Vehicle Product Liability	<input type="checkbox"/> 900 Appeal of Fee Determination Under Equal Access to Justice
	<input type="checkbox"/> 356 Other Personal Injury	<input type="checkbox"/> 380 Other Personal Property Damage	<input type="checkbox"/> 790 Other Labor Litigation	<input type="checkbox"/> 791 Empl. Ret. Inc. Security Act	<input type="checkbox"/> 865 FSI (405(g))	<b>FEDERAL TAX SUITS</b>	<input type="checkbox"/> 950 Constitutionality of State Statutes		<input type="checkbox"/> 890 Other Statutory Actions
		<input type="checkbox"/> 385 Property Damage Product Liability							
<b>REAL PROPERTY</b>	<b>CIVIL RIGHTS</b>	<b>PRISONER PETITIONS</b>							
<input type="checkbox"/> 210 Land Condemnation	<input type="checkbox"/> 441 Voting	<input type="checkbox"/> 510 Motions to Vary Sentence							
<input type="checkbox"/> 220 Foreclosure	<input type="checkbox"/> 442 Employment	<input type="checkbox"/> 530 General							
<input type="checkbox"/> 230 Rent Lease & Ejectment	<input type="checkbox"/> 443 Housing/Accommodations	<input type="checkbox"/> 535 Death Penalty							
<input type="checkbox"/> 240 Torts to Land	<input type="checkbox"/> 444 Welfare	<input type="checkbox"/> 540 Mandamus & Other							
<input type="checkbox"/> 245 Tort Product Liability	<input type="checkbox"/> 440 Other Civil Rights	<input type="checkbox"/> 550 Civil Rights							
<input type="checkbox"/> 290 All Other Real Property		<input type="checkbox"/> 555 Prison Condition							

**V. ORIGIN** (PLACE AN "X" IN ONE BOX ONLY)

- ☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify) ☐ 6 Multidistrict Litigation ☐ 7 Appeal to District Judge from Magistrate's Judgment

**VI. CAUSE OF ACTION** (Cite the U.S. Civil Statute under which you are filing and write brief statement of cause. Do not cite jurisdictional statutes unless diversity.)

35 U.S.C. § 271 for patent infringement and 28 U.S.C. § 1338(a).

**VII. REQUESTED IN COMPLAINT:**

**CHECK IF THIS IS A CLASS ACTION  
UNDER F.R.C.P. 23**

**DEMAND \$**

CHECK YES only if demanded in complaint:

**JURY DEMAND:** ☒ Yes ☐ No

**VIII. RELATED CASE(S)**  
**IF ANY**

**JUDGE**

DOCKET  
NUMBER

**DATE**

08/27/2007

**SIGNATURE OF ATTORNEY OF RECORD**

**FOR OFFICE USE ONLY**

RECEIPT #

AMOUNT

## APPLYING IEP

**JUDGE**

MAG. JUDGE

JS 44 Reverse (Rev. 12/96)

**INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS-44****Authority For Civil Cover Sheet**

The JS-44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

**I. (a) Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

**(b.) County of Residence.** For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

**(c) Attorneys.** Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

**II. Jurisdiction.** The basis of jurisdiction is set forth under Rule 8(a), F.R.C.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.

United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States, are included here.

United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.

Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.

Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below; federal question actions take precedence over diversity cases.)

**III. Residence (citizenship) of Principal Parties.** This section of the JS-44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

**IV. Nature of Suit.** Place an "X" in the appropriate box. If the nature of suit cannot be determined, be sure the cause of action, in Section IV below, is sufficient to enable the deputy clerk or the statistical clerks in the Administrative Office to determine the nature of suit. If the cause fits more than one nature of suit, select the most definitive.

**V. Origin.** Place an "X" in one of the seven boxes.

Original Proceedings. (1) Cases which originate in the United States district courts.

Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441. When the petition for removal is granted, check this box.

Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.

Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.

Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a) Do not use this for within district transfers or multidistrict litigation transfers.

Multidistrict Litigation. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407. When this box is checked, do not check (5) above.

Appeal to District Judge from Magistrate Judgment. (7) Check this box for an appeal from a magistrate judge's decision.

**VI. Cause of Action.** Report the civil statute directly related to the cause of action and give a brief description of the cause.

**VII. Requested in Complaint. Class Action.** Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.

**Demand.** In this space enter the dollar amount (in thousands of dollars) being demanded or indicate other demand such as a preliminary injunction.

**Jury Demand.** Check the appropriate box to indicate whether or not a jury is being demanded.

**VIII. Related Cases.** This section of the JS-44 is used to reference related pending cases if any. If there are related pending cases, insert the docket numbers and the corresponding judge names for such cases.

**Date and Attorney Signature.** Date and sign the civil cover sheet.

AO FORM 85 RECEIPT (REV. 9/04)

United States District Court for the District of Delaware

Civil Action No. 07-516



FILED  
CLERK U.S. DISTRICT COURT  
DISTRICT OF DELAWARE

2007 AUG 27 AM 11:24

**ACKNOWLEDGMENT  
OF RECEIPT FOR AO FORM 85**

**NOTICE OF AVAILABILITY OF A  
UNITED STATES MAGISTRATE JUDGE  
TO EXERCISE JURISDICTION**

I HEREBY ACKNOWLEDGE RECEIPT OF 3 COPIES OF AO FORM 85.

AUG 27 2007

(Date forms issued)

Mike Bobish

(Signature of Party or their Representative)

Mike Bobish

(Printed name of Party or their Representative)

**Note: Completed receipt will be filed in the Civil Action**

# **EXHIBIT 3**

UNITED STATES PATENT AND TRADEMARK OFFICE  
CERTIFICATE OF CORRECTION

PATENT NO. : 7,173,922 B2  
APPLICATION NO. : 09/780741  
DATED : February 6, 2007  
INVENTOR(S) : Robert Beach

Page 1 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 17, lines 62-63, "providing a common cell controller coupled to a plurality of RE ports" should be changed to:

--providing a plurality of RF ports;  
separately housing a common cell controller from the plurality of RF ports--;

Column 17, line 65, "all of" should be deleted;

Column 17, line 67 - Column 18, line 2, "wherein each RF port is configured to perform low level medium access control (MAC) functions and" should be changed to --in accordance with a wireless communication standard protocol having higher and lower level medium access control (MAC) functions, wherein--;

Column 18, line 3, "high level" should be changed to --the higher level--;

Column 18, line 3, "coupled" should be deleted;

Column 18, line 8, "," should be changed to --;--;

Column 18, line 9, "are operated to perform low level" should be changed to: --operate to perform the lower level--;

Column 18, line 13, "is operated" should be changed to --operates--;

Column 18, line 17, "two" should be changed to --two of the--;

Column 18, line 20, "a wireless local area network" should be changed to --multiple wireless local area networks--;

Column 18, line 21, "sent," should be changed to --sent--;

Column 18, line 22, "first data protocol" should be changed to --communication protocol other than the wireless communication standard protocol--;

Column 18, line 24, "a second data protocol" should be changed to --the wireless communication standard protocol--;

Column 18, line 25, "controllers" should be changed to --controller--;

Column 18, line 26, "first data protocol" should be changed to --communication protocol--;



UNITED STATES PATENT AND TRADEMARK OFFICE  
CERTIFICATE OF CORRECTION

PATENT NO. : 7,173,922 B2  
APPLICATION NO. : 09/780741  
DATED : February 6, 2007  
INVENTOR(S) : Robert Beach

Page 2 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, line 27, "second data protocol" should be changed to --the wireless communication standard protocol--;

Column 18, line 28, "a wireless local area network" should be changed to --multiple wireless local area networks--;

Column 18, line 29, "first" should be changed to --communication--;

Column 18, line 31, "a wireless local area network" should be changed to --multiple wireless local area networks--;

Column 18, line 32, "second" should be changed to --wireless communication standard--;

Column 18, line 33, "Standard 802.11" should be changed to --802.11 standard--;

Column 18, line 34, "a wireless local area network" should be changed to --multiple wireless local area networks--;

Column 18, line 35, "4" should be changed to --1--;

Column 18, line 35, "two" should be changed to --two of the--;

Column 18, line 38, "a wireless local area network" should be changed to --multiple wireless local area networks--;

Column 18, line 45, "," should be changed to --;-;

Column 18, line 48, "," should be changed to --;-;

Column 18, lines 51-53, "at least two wireless local area subnetworks occupying common physical space" should be changed to --the at least two of the overlapping wireless local area subnetworks--;

Column 19, line 15, "form" should be changed to --from--;

Column 19, line 21, "functions" should be changed to --functions of a wireless communication standard protocol--;

Column 19, line 22, "entity" should be changed to --entity housed separately from said RF port--;

UNITED STATES PATENT AND TRADEMARK OFFICE  
CERTIFICATE OF CORRECTION

PATENT NO. : 7,173,922 B2  
APPLICATION NO. : 09/780741  
DATED : February 6, 2007  
INVENTOR(S) : Robert Beach

Page 3 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 19, line 23, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 19, line 25, "high level" should be changed to --the high level--;

Column 19, line 28, "high level" should be changed to --the high level--;

Column 19, line 43, "radio module" should be changed to --RF module--;

Column 19, line 46, "coupled to a wired network" should be changed to --separately housed from a wired network and coupled to the wired network--;

Column 19, line 48, "functions" should be changed to --functions of a wireless communication standard protocol--;

Column 19, line 50, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 19, line 60, "high level" should be changed to --the high level--;

Column 19, lines 66-67, "coupled to a wired network" should be changed to --separately housed from a wired network and coupled to the wired network--;

Column 20, line 2, "functions" should be changed to --functions of a wireless communication standard protocol--;

Column 20, line 3, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 20, line 15, "high level" should be changed to --the high level--;

Column 20, line 26, "radio module" should be changed to --RF module--;

Column 20, line 30, "RF ports" should be changed to --RF ports separately housed from said computer--;

Column 20, line 35, "functions" should be changed to --functions of a wireless communication standard protocol--;

Column 20, line 35, "RF parts" should be changed to --RF ports--;

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 7,173,922 B2  
 APPLICATION NO. : 09/780741  
 DATED : February 6, 2007  
 INVENTOR(S) : Robert Beach

Page 4 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 20, line 40, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 20, line 54, "comprising" should be changed to --comprising--;

Column 20, lines 55-56, "communications system and an RF port" should be changed to --communication system and an RF port separately housed from said communication system--;

Column 20, line 56, "comprising" should be changed to --comprising--;

Column 20, line 58, "to" should be changed to --to--;

Column 20, line 59, ", to" should be changed to --,--;

Column 20, line 60, "communications and to" should be changed to --communications--;

Column 20, line 64, "space, and to" should be changed to --space--;

Column 20, line 66, "space, and to" should be changed to --space--;

Column 21, line 2, "functions" should be changed to --functions of a wireless communication standard protocol--;

Column 21, line 3, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 21, lines 18-20, "providing a modem coupled to the Internet and having a data communications interface connected to an RF port" should be changed to:

--coupling a cell controller to the Internet;  
 coupling a data communications interface of a modem to the Internet;  
 separately housing said cell controller from an RF port;  
 coupling the RF port to the data communications interface,--;

Column 21, line 23, "," should be changed to --,--;

Column 21, line 31, "functions" should be changed to --functions of a wireless communications standard protocol--;

UNITED STATES PATENT AND TRADEMARK OFFICE  
CERTIFICATE OF CORRECTION

PATENT NO. : 7,173,922 B2  
APPLICATION NO. : 09/780741  
DATED : February 6, 2007  
INVENTOR(S) : Robert Beach

Page 5 of 5

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 21, line 31, "Internet" should be changed to --cell controller--;

Column 21, line 32, "functions" should be changed to --functions of the wireless communication standard protocol--;

Column 21, line 38, "protocol" should be changed to --standard protocol--;

Column 21, lines 41-42, "performing lower level MAC functions" should be changed to --configured to perform lower level MAC functions of the wireless data communications standard protocol--;

Column 21, line 44, "using capable of operating" should be deleted;

Column 21, lines 51-52, "said RF communications protocol" should be changed to --an RF communications protocol--;

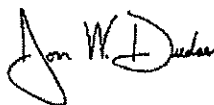
Column 22, line 3, "controller" should be changed to --controller separately housed from said at least one RF port--;

Column 22, line 6, "functions" should be changed to --functions of the wireless data communications standard protocol--; and

Column 22, line 21, "data packet" should be changed to --a data packet--.

Signed and Sealed this

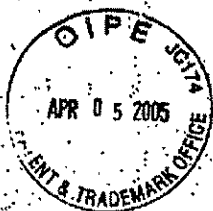
Thirty-first Day of July, 2007



JON W. DUDAS  
Director of the United States Patent and Trademark Office

# **EXHIBIT 4**

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Docket No. \_\_\_\_\_ In re: ☒ patent/ \_\_\_\_\_ trademark application of

Applicant(s) T. Rappaport et al

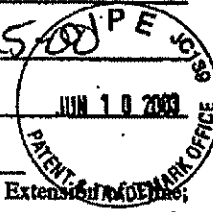
Serial No. 09/668145 Date Filed 9-25-00

Papers filed herewith on 6-10-03

Fees \$ \_\_\_\_\_ Deposit Account No. (if applicable) \_\_\_\_\_  
 ( \_\_\_\_\_ filing fee; \_\_\_\_\_ Assignment charge; \_\_\_\_\_ Extension fee;  
 \_\_\_\_\_ issue fee/advance copies; \_\_\_\_\_ other \_\_\_\_\_ )

\_\_\_\_\_ Amendment \_\_\_\_\_ Notice of Appeal \_\_\_\_\_ Appeal Brief  
 \_\_\_\_\_ Sheets of \_\_\_\_\_ Drawings \_\_\_\_\_ Proposed Drawing Corrections (w/ \_\_\_\_\_ drawings)  
 \_\_\_\_\_ Change of Address \_\_\_\_\_ Request for Extension of Time  
 \_\_\_\_\_ Assignment \_\_\_\_\_ Recordation Form Cover Sheet  
☒ Information Disclosure Statement ☒ PTO-1449 and associated art ( 157 docs.)  
 \_\_\_\_\_ Priority Document(s) \_\_\_\_\_ Other \_\_\_\_\_

02560038AA MEW:CMA





02560038AA



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

T. RAPPAPORT ET AL.

Serial No.: 09/668,145

Group Art Unit: 2122

Filed: September 25, 2000

Examiner: not yet assigned

For: SYSTEM AND METHOD FOR DESIGN, TRACKING, MEASUREMENT,  
PREDICTION AND OPTIMIZATION OF DATA COMMUNICATION NETWORKS

Commissioner for Patents  
PO Box 1450  
Alexandria, Virginia 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

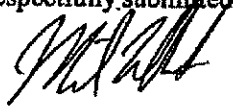
Under the provisions of 37 C.F.R. 1.97 through 1.99 and pursuant to applicant's duty of disclosure under 37 C.F.R. 1.56, applicant respectfully brings the following documents, listed on the attached form PTO-1449, to the attention of the Examiner in charge of the above-identified application. Copies of the listed documents are provided herewith for the convenience of the Examiner.

This citation does not constitute an admission that the references are relevant or material to the claims. They are only cited as constituting related art of which the applicant is aware.

It is respectfully requested that the listed references be considered by the Examiner and formally made of record in this application.

Please charge any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 50-2041.

Respectfully submitted,



Michael E. Whitham  
Registration No.: 32,635

Whitham, Curtis & Christofferson, PC  
11491 Sunset Hills Road, Suite 340  
Reston, Virginia 20190  
703-787-9400

## INFORMATION DISCLOSURE CITATION

(Use several sheets if necessary)

Docket Number (Optional) <b>02560038AA</b>	Application Number <b>09/668,145</b>
Applicant(s) <b>T. Rappaport et al.</b>	
Filing Date <b>9/25/00</b>	Group Art Unit

APR 05 2005

## U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1	4,675,147	6-23-87	Schaefer et al.			4-6-83
	2	4,736,453	4-5-88	Schloemer			12-10-85
	3	4,885,694	12-5-89	Pray et al.			4-29-87
	4	5,111,392	5-5-92	Malin			6-9-89
	5	5,119,307	6-2-92	Blaha et al.			12-22-89
	6	5,239,487	8-24-93	Horejsi et al.			10-24-90
	7	5,293,640	3-8-94	Gunmar et al.			
	8	5,307,261	4-26-94	Maki et al.			6-28-91
	9	5,337,149	8-9-94	Kozah et al.			11-12-92
	10	5,339,184	8-16-94	Tang			6-15-92
	11	5,375,123	12-20-94	Andersson et al.			2-5-93

## FOREIGN PATENT DOCUMENTS

REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

## OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)


EXAMINER

DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

**INFORMATION DISCLOSURE**  
*(Use several sheets if necessary)*

APR 05 2005

Docket Number (Optional)

02560038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

## U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE, IF APPROPRIATE
	12	5,394,522	2-28-95	Sanchez-Frank et al.			9-13-93
	13	5,450,615	9-12-95	Fortune et al.			12-22-93
	14	5,458,123	10-17-95	Unger			4-29-94
	15	5,465,390	11-7-95	Cohen			2-12-93
	16	5,482,050	1-9-96	Smokoff et al.			2-17-94
	17	5,485,568	1-16-96	Venable et al.			10-8-93
	18	5,491,644	2-13-96	Pickering et al.			9-7-93
	19	5,491,837	2-13-96	Haartsen			3-7-94
	20	5,493,679	2-20-96	Virgil et al.			10-29-93
	21	5,515,269	5-7-96	Willis et al.			11-8-93
	22	5,528,518	6-18-96	Bradshaw et al.			10-25-94

## FOREIGN PATENT DOCUMENTS

REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*


EXAMINER

DATE CONSIDERED

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Form PTO-A520

P09A/REV04

Patent and Trademark Office • U.S. DEPARTMENT OF COMMERCE

(also form PTO-1449)

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SHEET 2 OF 15

**INFORMATION DISCLOSURE**  
*(Use several sheets if necessary)*

APR 05 2005

Docket Number (Optional)

02560038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

## U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	23	5,539,665	7-23-96	Lamming et al.			7-25-94
	24	5,553,312	9-3-96	Gatley et al.			6-20-94
	25	5,553,620	9-10-96	Snider et al.			5-2-95
	26	5,555,354	9-10-96	Strasnick et al.			3-23-93
	27	5,561,841	10-1-96	Markus			
	28	5,564,070	10-8-96	Want et al.			7-30-93
	29	5,594,946	1-14-97	Menich et al.			2-28-95
	30	5,598,532	1-28-97	Liron			10-21-93
	31	5,625,827	4-29-97	Krause et al.			12-23-94
	32	5,636,344	6-3-97	Lewis			8-22-91
	33	5,689,355	11-18-97	Okubo et al.			7-1-96

## FOREIGN PATENT DOCUMENTS

REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*


EXAMINER

DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

 Form PTO-A820  
 (also form PTO-1449)

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P05A/REV04

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SHEET 3 OF 15

## INFORMATION DISCLOSURE

(Use several sheets if necessary)

APR 05 2005

Docket Number (Optional)

02560038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

## U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	34	5,761,093	6-2-98	Urbish et al.			5-8-97
	35	5,794,128	8-11-98	Brockel et al.			9-20-95
	36	5,799,154	8-25-98	Kuriyan			6-27-96
	37	5,809,282	8-15-98	Cooper et al.			6-7-95
	38	5,815,395	9-29-98	Hart et al.			6-29-95
	39	5,828,960	10-27-98	Tang et al.			3-31-95
	40	5,831,610	11-3-98	Tonelli et al.			2-23-96
	41	5,832,389	11-3-98	Dent			4-3-96
	42	5,861,887	1-19-99	Butler et al.			12-5-95
	43	5,867,112	2-2-99	Kost			5-14-91
	44	5,877,777	3-2-99	Colwell			4-7-97

## FOREIGN PATENT DOCUMENTS

REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

## OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)


EXAMINER

DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.



## INFORMATION DISCLOSURE CERTIFICATION

(Use separate sheets if necessary)

APR 05 2005

Docket Number (Optional)

02560038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

## U.S. PATENT DOCUMENTS

EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	45	5,878,328	3-2-99	Chawla et al.			12-21-95
	46	5,907,850	5-25-99	Krause et al.			1-21-97
	47	5,917,808	6-29-99	Kosbab			1-17-97
	48	5,923,850	7-13-99	Barroux			6-28-96
	49	5,926,762	7-20-99	Arpee et al.			5-17-96
	50	5,940,196	8-17-99	Piehler et al.			5-16-97
	51	5,945,976	8-31-99	Iwamura et al.			12-10-96
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	55	5,953,669	9-14-99	Stratis et al.			12-11-97

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REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

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DATE CONSIDERED

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# INFORMATION DISCLOSURE CITATION

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APR 05 2005

PATENT &amp; TRADEMARK OFFICE

Docket Number (Optional)

02560038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

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	56	5,963,867	10-5-99	Reynolds et al.			8-16-95
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	59	6,006,021	12-21-99	Tognazzini			7-1-96
	60	6,018,625	1-25-00	Hayball et al.			8-27-97
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						YES	NO

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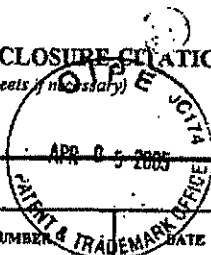

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Docket Number (Optional) <b>02560038AA</b>	Application Number <b>09/668,145</b>
Applicant(s) <b>T. Rappaport et al.</b>	
Filing Date <b>9/25/00</b>	Group Art Unit

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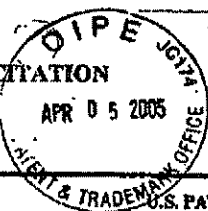
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T. Rappaport et al.

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02560038AA

Application Number

09/668,145

Applicant(s)

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	90	6,393,432	5-21-02	Flansburg et al.			6-2-99
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## FOREIGN PATENT DOCUMENTS

REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

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Docket Number (Optional)

0256038AA

Application Number

09/668,145

Applicant(s)

T. Rappaport et al.

Filing Date

9/25/00

Group Art Unit

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	100	6,085,335	7-4-00	Djoko et al.			12-31-97
	101	5,710,758	1-20-98	Soliman et al.			9-29-95
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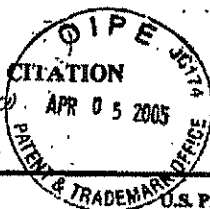
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02560038AA	09/668,145
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T. Rappaport et al.	
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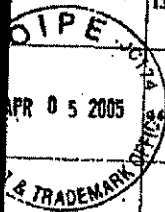
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Docket Number (Optional) <b>02560038AA</b>	Application Number <b>09/668,145</b>
Applicant(s) <b>T. Rappaport et al.</b>	
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02560038AA

Application Number

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Applicant(s)

T. Rappaport et al.

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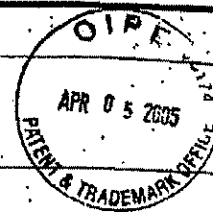
## INFORMATION DISCLOSURE CITATION

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Docket Number (Optional) <b>02560038AA</b>	Application Number <b>09/668,145</b>
Applicant(s) <b>T. Rappaport et al.</b>	
Filing Date <b>9/25/00</b>	Group Art Unit

EXAMINER INITIAL	OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)
	Company Web Page "Actix" www.actix.com product name: E-NOS (now E-AMS)
	Company Web Page "Agilent" www.agilent.com product name: OPAS32
	Company Web Page "Agilent" www.agilent.com product name: Wizard
	Company Web Page "Comarco" www.edx.com product name: SignalPro
	Company Web Page "ComOpt" www.comopt.com product name: CellOpt AFP
	Company Web Page "Lucent" www.bell-labs.com product name: WISE
	Company Web Page "Ericsson" www.ericsson.com product name: TEMS Lite
	Company Web Page "Ericsson" www.ericsson.com product name: TEMS
	Company Web Page "Marconi" www.marconi.com product name: PLANET
	Company Web Page "Marconi" www.marconi.com product name: decibelPlanner
	Company Web Page "Schema" www.schema.com product name: Optimizer
	Company Web Page "ScoreBoard" www.scoreboard.com product name: ScoreBoard
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# **EXHIBIT 5**



608.05(c)

## MANUAL OF PATENT EXAMINING PROCEDURE

or as part of the specification in paper (in compliance with 37 CFR 1.52).

A single table contained on 51 pages or more may be submitted on a CD-ROM or CD-R (in compliance with 37 CFR 1.52(e) and 37 CFR 1.58). The presentation of a subheading to divide a large table into smaller sections of less than 51 pages should not be used to prevent an applicant from submitting the table on a compact disc unless the subdivided tables are presented as numerous files on the compact disc so as to lose their relationship to the overall large table.

Form paragraphs 6.63.01 and 6.63.02 may be used to notify applicant of corrections needed to comply with the requirements of 37 CFR 1.52(e) and 37 CFR 1.58(b) with respect to tables.

**¶ 6.63.01 CD-ROM/CD-R Requirements (Table Listing in Specification)**

The description portion of this application contains a table consisting of less than fifty one (51) pages only on a CD-ROM or CD-R. In accordance with 37 CFR 1.52(e), only a table of at least fifty one (51) pages may be submitted on a CD-ROM or CD-R. Accordingly, applicant is required to cancel the references to the CD-ROM/CD-R table appearing in the specification on pages[1], file a paper version of the table in compliance with 37 CFR 1.52 and change all appropriate references to the former CD-ROM/CD-R table to the newly added paper version of the table in the remainder of the specification

**Examiner Note:**

1. This form paragraph must be used whenever an application filed on or after November 7, 2000 contains a table on a CD-ROM or CD-R consisting of less than fifty one (51) pages as part of the descriptive portion of the specification.
2. In bracket 1, insert the range of page numbers of the specification which reference the table.

**¶ 6.63.02 Table on CD-ROM/CD-R Column/Row Relationship Not Maintained**

This application contains a table on CD-ROM/CD-R. Tables presented on CD-ROM/CD-R in compliance with 37 CFR 1.58 must maintain the spacial orientation of the cell entries. The table submitted does not maintain the data within each table cell in its proper row/column alignment. The data is misaligned in the table as follows: [1]. Applicant is required to submit a replacement compact disc with the table data properly aligned.

**Examiner Note:**

1. This form paragraph must be used whenever the data in a table cannot be accurately read because the data in the table cells do not maintain their row and column alignments.
2. In bracket 1, insert the area of the table that does not maintain the row and column alignments.

**608.05(c) Compact Disc Submissions of Biosequences**

Filing of biosequence information on compact disc is now permitted in lieu of filing on paper. See MPEP § 2420 and § 2422.03.

**609 Information Disclosure Statement**

**37 CFR 1.97. Filing of information disclosure statement.**

(a) In order for an applicant for a patent or for a reissue of a patent to have an information disclosure statement in compliance with § 1.98 considered by the Office during the pendency of the application, the information disclosure statement must satisfy one of paragraphs (b), (c), or (d) of this section.

(b) An information disclosure statement shall be considered by the Office if filed by the applicant within any one of the following time periods:

(1) Within three months of the filing date of a national application other than a continued prosecution application under § 1.53(d);

(2) Within three months of the date of entry of the national stage as set forth in § 1.491 in an international application;

(3) Before the mailing of a first Office action on the merits; or

(4) Before the mailing of a first Office action after the filing of a request for continued examination under § 1.114.

(c) An information disclosure statement shall be considered by the Office if filed after the period specified in paragraph (b) of this section, provided that the information disclosure statement is filed before the mailing date of any of a final action under § 1.113, a notice of allowance under § 1.311, or an action that otherwise closes prosecution in the application, and it is accompanied by one of:

(1) The statement specified in paragraph (e) of this section; or

(2) The fee set forth in § 1.17(p).

(d) An information disclosure statement shall be considered by the Office if filed by the applicant after the period specified in paragraph (c) of this section, provided that the information disclosure statement is filed on or before payment of the issue fee and is accompanied by:

(1) The statement specified in paragraph (e) of this section; and

(2) The fee set forth in § 1.17(p).

(e) A statement under this section must state either:

(1) That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement; or

(2) That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making

## PARTS, FORM, AND CONTENT OF APPLICATION

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reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of the information disclosure statement.

(f) No extensions of time for filing an information disclosure statement are permitted under § 1.136. If a *bona fide* attempt is made to comply with § 1.98, but part of the required content is inadvertently omitted, additional time may be given to enable full compliance.

(g) An information disclosure statement filed in accordance with section shall not be construed as a representation that a search has been made.

(h) The filing of an information disclosure statement shall not be construed to be an admission that the information cited in the statement is, or is considered to be, material to patentability as defined in § 1.56(b).

(i) If an information disclosure statement does not comply with either this section or § 1.98, it will be placed in the file but will not be considered by the Office.

**37 CFR 1.98. Content of information disclosure statement.**

(a) Any information disclosure statement filed under § 1.97 shall include:

(1) A list of all patents, publications, applications, or other information submitted for consideration by the Office;

(2) A legible copy of:

(i) Each U.S. patent application publication and U.S. and foreign patent;

(ii) Each publication or that portion which caused it to be listed;

(iii) For each cited pending U.S. application, the application specification including the claims, and any drawing of the application, or that portion of the application which caused it to be listed including any claims directed to that portion; and

(iv) All other information or that portion which caused it to be listed; and

(3)(i) A concise explanation of the relevance, as it is presently understood by the individual designated in § 1.56(c) most knowledgeable about the content of the information, of each patent, publication, or other information listed that is not in the English language. The concise explanation may be either separate from applicant's specification or incorporated therein.

(ii) A copy of the translation if a written English-language translation of a non-English-language document, or portion thereof, is within the possession, custody, or control of, or is readily available to any individual designated in § 1.56(c).

(b)(1) Each U.S. patent listed in an information disclosure statement must be identified by inventor, patent number, and issue date.

(2) Each U.S. patent application publication listed in an information disclosure statement shall be identified by applicant, patent application publication number, and publication date.

(3) Each U.S. application listed in an information disclosure statement must be identified by the inventor, application number, and filing date.

(4) Each foreign patent or published foreign patent application listed in an information disclosure statement must be identified by the country or patent office which issued the patent or

published the application, an appropriate document number, and the publication date indicated on the patent or published application.

(5) Each publication listed in an information disclosure statement must be identified by publisher, author (if any), title, relevant pages of the publication, date, and place of publication.

(c) When the disclosures of two or more patents or publications listed in an information disclosure statement are substantively cumulative, a copy of one of the patents or publications may be submitted without copies of the other patents or publications, provided that it is stated that these other patents or publications are cumulative.

(d) A copy of any patent, publication, pending U.S. application or other information, as specified in paragraph (a) of this section, listed in an information disclosure statement is required to be provided, even if the patent, publication, pending U.S. application or other information was previously submitted to, or cited by, the Office in an earlier application, unless:

(1) The earlier application is properly identified in the information disclosure statement and is relied on for an earlier effective filing date under 35 U.S.C. 120; and

(2) The information disclosure statement submitted in the earlier application complies with paragraphs (a) through (c) of this section.

Information Disclosure Statements (IDSs) are not permitted in provisional applications filed under 35 U.S.C. 111(b). See 37 CFR 1.51(d). Since no substantive examination is given in provisional applications, a disclosure of information is unnecessary. Any such statement filed in a provisional application will be returned or destroyed at the option of the Office.

In applications filed under 35 U.S.C. 111(a), applicants and other individuals substantively involved with the preparation and/or prosecution of the application have a duty to submit to the Office information which is material to patentability as defined in 37 CFR 1.56. The provisions of 37 CFR 1.97 and 37 CFR 1.98 provide a mechanism by which patent applicants may comply with the duty of disclosure provided in 37 CFR 1.56. Applicants and other individuals substantively involved with the preparation and/or prosecution of the patent application also may want the Office to consider information for a variety of other reasons; e.g., to make sure that the examiner has an opportunity to consider the same information that was considered by these individuals, or by another patent office in a counterpart or related patent application filed in another country.

An information disclosure statement filed in accordance with the provisions of 37 CFR 1.97 and 37 CFR 1.98 will be considered by the examiner assigned to the application. The requirements for the content of a

statement have been simplified in the rules, to encourage individuals associated in a substantive way with the filing and prosecution of a patent application to submit information to the Office so the examiner can evaluate its relevance to the claimed invention. The procedures for submitting an information disclosure statement under the rules are designed to encourage individuals to submit information to the Office promptly and in a uniform manner. These rules provide certainty for the public by defining the requirements for submitting information disclosure statements to the Office so that the Office will consider information contained therein before a patent is granted.

The filing of an information disclosure statement shall not be construed as a representation that a search has been made. 37 CFR 1.97(g). There is no requirement that an applicant for a patent make a patentability search. Further, the filing of an information disclosure statement shall not be construed to be an admission that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 CFR 1.56(b). 37 CFR 1.97(h). See MPEP § 2129 regarding admissions by applicant.

In order to have information considered by the Office during the pendency of a patent application, an information disclosure statement must be (1) in compliance with the content requirements of 37 CFR 1.98, and (2) filed in accordance with the procedural requirements of 37 CFR 1.97. The requirements as to content are discussed in subsection III.A below. The requirements based on the time of filing the statement are discussed in subsection III.B below. Examiner handling of information disclosure statements is discussed in subsection III.C below.

Once the minimum requirements of 37 CFR 1.97 and 37 CFR 1.98 are met, the examiner has an obligation to consider the information. Consideration by the examiner of the information submitted in an IDS means nothing more than considering the documents in the same manner as other documents in Office search files are considered by the examiner while conducting a search of the prior art in a proper field of search. The initials of the examiner placed adjacent to the citations on the PTO-1449 or PTO/SB/08A and 08B or its equivalent mean that the information has been considered by the examiner to the extent noted above. Only where the relevancy of the information is

actually discussed in the application file (either by the examiner or by the applicant) or where the information is relied upon to reject a claim in the application, will the information deemed to have been "considered" (to the extent discussed) for the purposes of reexamination under the *Portola* guidelines. See MPEP § 2242 under the subsection "General Principles Governing Compliance With Portola Packaging." Information submitted to the Office that does not comply with the requirements of 37 CFR 1.97 and 37 CFR 1.98 will not be considered by the Office but will be placed in the application file.

Multiple information disclosure statements may be filed in a single application, and they will be considered, provided each is in compliance with the appropriate requirements of 37 CFR 1.97 and 37 CFR 1.98. Use of form PTO-1449, "Information Disclosure Citation," or PTO/SB/08A and 08B, "Information Disclosure Statement," is encouraged as a means to provide the required list of information as set forth in 37 CFR 1.98(a)(1). Applicants are encouraged to use the USPTO forms when preparing an information disclosure statement. A copy of forms PTO-1449, "Information Disclosure Citation" and PTO/SB/08A and 08B are reproduced at the end of this section to indicate how the forms should be completed. The forms will enable applicants to comply with the requirement to list each item of information being submitted and to provide the Office with a uniform listing of citations and with a ready way to indicate that the information has been considered.

## I. IDS IN CONTINUED EXAMINATIONS OR CONTINUING APPLICATIONS

### A. *IDS That Has Been Considered (1) In The Parent Application, Or (2) Prior To The Filing Of A Request For Continued Examination (RCE)*

#### 1. Continued Prosecution Applications (CPAs) Filed Under 37 CFR 1.53(d) Or File Wrapper Continuing (FWC) Applications Filed Under Former 37 CFR 1.62

Information which has been considered by the Office in the parent application of a continued prosecution application (CPA) filed under 37 CFR 1.53(d), or a file wrapper continuing application (FWC) filed prior to December 1, 1997 under former 37 CFR 1.62,

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will be part of the file before the examiner and need not be resubmitted in the continuing application to have the information considered and listed on the patent.

**2. Continuation Applications or Divisional Applications, Filed Under 37 CFR 1.53(b) Or Filed Under Former 37 CFR 1.60, Or Continuation-In-Part Applications Filed Under 37 CFR 1.53(b)**

The examiner will consider information which has been considered by the Office in a parent application when examining (A) a continuation application filed under 37 CFR 1.53(b) or filed under former 37 CFR 1.60, (B) a divisional application filed under 37 CFR 1.53(b) or filed under former 37 CFR 1.60, or (C) a continuation-in-part application filed under 37 CFR 1.53(b). Such information need not be resubmitted in the continuing application unless the applicant desires the information to be printed on the patent.

**3. Requests For Continued Examination (RCE) Under 37 CFR 1.114**

Information which has been considered by the Office in the application before the filing of a RCE will be part of the file before the examiner and need not be resubmitted to have the information considered by the examiner and listed on the patent.

**B. IDS That Has Not Been Considered (1) In The Parent Application, Or (2) Prior To The Filing Of A Request For Continued Examination**

**1. Continued Prosecution Applications Filed Under 37 CFR 1.53(d)**

Information filed in the parent application that complies with the content requirements of 37 CFR 1.98 will be considered by the examiner in the CPA. No specific request from the applicant that the previously submitted information be considered by the examiner is required.

**2. File Wrapper Continuing Application Filed Under Former 37 CFR 1.62**

For FWC applications filed prior to December 1, 1997 under former 37 CFR 1.62, in order to ensure consideration of information complying with the content requirements of 37 CFR 1.98 previously submit-

ted, but not considered, in a parent application, applicant must either specifically request that the previously submitted information be considered in the FWC or resubmit the information in the FWC in compliance with 37 CFR 1.97 and 37 CFR 1.98.

**3. Continuation Applications or Divisional Applications, Filed Under 37 CFR 1.53(b) Or Filed Under Former 37 CFR 1.60, Or Continuation-In-Part Applications Filed Under 37 CFR 1.53(b)**

For these types of applications, in order to ensure consideration of information previously submitted, but not considered, in a parent application, applicant must resubmit the information in the continuing application in compliance with 37 CFR 1.97 and 37 CFR 1.98.

**4. Requests For Continued Examination Under 37 CFR 1.114**

Information filed in the application in compliance with the content requirements of 37 CFR 1.98 before the filing of a RCE will be considered by the examiner after the filing of the RCE. For example, an applicant filed an IDS in compliance with 37 CFR 1.98 after the mailing of a final Office action, but the IDS did not comply with the requirements of 37 CFR 1.97(d)(1) and (d)(2) and therefore, the IDS was not considered by the examiner. After applicant files a RCE, the examiner will consider the IDS filed prior to the filing of the RCE. For more details on RCE, see MPEP § 706.07(h).

## II. NATIONAL STAGE APPLICATIONS

The examiner will consider the documents cited in the international search report in a PCT national stage application when the Form PCT/DO/EO/903 indicates that both the international search report and the copies of the documents are present in the national stage file. In such a case, the examiner should consider the documents from the international search report and indicate by a statement in the first Office action that the information has been considered. There is no requirement that the examiner list the documents on a PTO-892 form.

In a national stage application, the following form paragraphs may be used where appropriate to notify



applicant regarding references listed in the search report of the international application:

**¶ 6.53 References Considered in 37 U.S.C. 371 Application Based Upon Search Report - Prior to Allowance**

The references cited in the Search Report [1] have been considered, but will not be listed on any patent resulting from this application because they were not provided on a separate list in compliance with 37 CFR 1.98(a)(1). In order to have the references printed on such resulting patent, a separate listing, preferably on a PTO-1449 or PTO/SB/08A and 08B form, must be filed within the set period for reply to this Office action.

**Examiner Note:**

1. This form paragraph may be used for PCT National Stage applications submitted under 35 U.S.C. 371 where the examiner has obtained copies of the cited references. For applications filed from US, JPO or EPO search authorities, the copies of the references should be supplied by those offices under the trilateral agreement. However, if receipt of such copies is not indicated on the PCT/DO/EO/903 form in the file, burden is on the applicant to supply copies for consideration. See MPEP § 1893.03(g).
2. Instead of using this form paragraph, the examiner may list the references on a PTO-892, thereby notifying the applicant that the references have been considered and will be printed on any patent resulting from this application.
3. This form paragraph should only be used prior to allowance when a statutory period for reply is being set in the Office action.
4. If the application is being allowed, form paragraph 6.54 should be used with the Notice of Allowability instead of this form paragraph.

**¶ 6.54 References Considered in 37 U.S.C. 371 Application Based Upon Search Report - Ready for Allowance**

The references cited in the Search Report [1] have been considered, but will not be listed on any patent resulting from this application because they were not provided on a separate list in compliance with 37 CFR 1.98(a)(1). In order to have the references printed on such resulting patent, a separate listing, preferably on a PTO-1449 or PTO/SB/08A and 08B form, must be filed within ONE MONTH of the mailing date of this communication. NO EXTENSION OF TIME WILL BE GRANTED UNDER EITHER 37 CFR 1.136(a) OR (b) to comply with this requirement.

**Examiner Note:**

1. See the Examiner Note for form paragraph 6.53.

**¶ 6.55 References Not Considered in 37 U.S.C. 371 Application Based Upon Search Report**

The listing of references in the Search Report is not considered to be an information disclosure statement (IDS) complying with 37 CFR 1.98. 37 CFR 1.98(a)(2) requires a legible copy of: (1) each U.S. and foreign patent; (2) each publication or that portion which caused it to be listed; (3) for each cited pending U.S. application, the application specification including claims, and any

drawing of the application, or that portion of the application which caused it to be listed including any claims directed to that portion; and (4) all other information, or that portion which caused it to be listed. In addition, each IDS must include a list of all patents, publications, applications, or other information submitted for consideration by the Office (see 37 CFR 1.98(a)(1) and (b)), and MPEP § 609 A(1) states, "the list ... must be submitted on a separate paper." Therefore, the references cited in the Search Report have not been considered. Applicant is advised that the date of submission of any item of information or any missing element(s) will be the date of submission for purposes of determining compliance with the requirements based on the time of filing the IDS, including all "statement requirements of 37 CFR 1.97(e). See MPEP § 609 subsection III C(1).

**Examiner Note:**

1. This form paragraph may be used in National Stage applications submitted under 35 U.S.C. 371 where the international searching authority was not the US, EPO or JPO.

**III. MINIMUM REQUIREMENTS FOR AN INFORMATION DISCLOSURE STATEMENT**

**A. Content**

An information disclosure statement must comply with the provisions of 37 CFR 1.98 as to content for the information listed in the IDS to be considered by the Office. Each information disclosure statement must comply with the applicable provisions of subsection III.A(1), A(2), and A(3) below.

**A (1) List of All Patents, Publications, U.S. Applications, or Other Information**

Each information disclosure statement must include a list of all patents, publications, U.S. applications, or other information submitted for consideration by the Office.

37 CFR 1.98(b) requires that each item of information in an IDS be identified properly. U.S. patents must be identified by the inventor, patent number, and issue date. U.S. patent application publications must be identified by the applicant, patent application publication number, and publication date. U.S. applications must be identified by the inventor, the eight digit application number (the two digit series code and the six digit serial number), and the filing date. If a U.S. application being listed in an IDS has been issued as a patent, the applicant should list the patent in the IDS instead of the application. Each foreign patent or published foreign patent application must be identified by

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the country or patent office which issued the patent or published the application, an appropriate document number, and the publication date indicated on the patent or published application. Each publication must be identified by publisher, author (if any), title, relevant pages of the publication, and date and place of publication. The date of publication supplied must include at least the month and year of publication, except that the year of publication (without the month) will be accepted if the applicant points out in the information disclosure statement that the year of publication is sufficiently earlier than the effective U.S. filing date and any foreign priority date so that the particular month of publication is not in issue. The place of publication refers to the name of the journal, magazine, or other publication in which the information being submitted was published.

The list of information complying with the identification requirements of 37 CFR 1.98(b) may not be incorporated into the specification of the application in which it is being supplied, but must be submitted in a separate paper. A separate list is required so that it is easy to confirm that applicant intends to submit an information disclosure statement and because it provides a readily available checklist for the examiner to indicate which identified documents have been considered. A copy of a separate list (generated by the Office) will also provide a simple means of communication to applicant to indicate the listed documents that have been considered and those listed documents that have not been considered. Use of either form PTO-1449, Information Disclosure Citation, or PTO/SB/08A and 08B, Information Disclosure Statement, to list the documents is encouraged. See subsection C(2) below.

#### **A (2) Legible Copies**

In addition to the list of information, each information disclosure statement must also include a legible copy of:

(A) Each U.S. patent application publication, and U.S. and foreign patent;

(B) Each publication or that portion which caused it to be listed;

(C) For each cited pending U.S. application, the application specification including the claims, and any drawings of the application, or that portion of the application which caused it to be listed including any claims directed to that portion; and

(D) All other information or that portion which caused it to be listed.

37 CFR 1.98(a)(2)(iii) requires a copy of a pending U.S. application that is being cited in an IDS. If the pending U.S. application is only identified in the specification's background information rather than being part of an IDS submission, a copy need not be supplied. Pursuant to 37 CFR 1.98(a)(2)(iii), applicant may choose to cite only a portion of a pending application including any claims directed to that portion rather than the entire application.

There are exceptions to this requirement that a copy of the information must be provided. First, 37 CFR 1.98(d) states that a copy of any patent, publication, pending U.S. application, or other information listed in an information disclosure statement is not required to be provided if: (1) the information was previously cited by or submitted to, the Office in a prior application, provided that the prior application is properly identified in the IDS and is relied on for an earlier filing date under 35 U.S.C. 120; and (2) the IDS submitted in the earlier application complies with 37 CFR 1.98(a)-(c). If both of these conditions are met, the examiner will consider the information previously cited or submitted to the Office and considered by the Office in a prior application relied on under 35 U.S.C. 120. This exception to the requirement for copies of information does not apply to information which was cited in an international application under the Patent Cooperation Treaty. If the information cited or submitted in the prior application was not in English, a concise explanation of the relevance of the information to the new application is not required unless the relevance of the information differs from its relevance as explained in the prior application. See subsection III.A(3) below.



Second, 37 CFR 1.98(c) states that when the disclosures of two or more patents or publications listed in an information disclosure statement are substantively cumulative, a copy of one of the patents or publications may be submitted without copies of the other patents or publications provided that a statement is made that these other patents or publications are cumulative. The examiner will then consider only the patent or publication of which a copy is submitted and will so indicate on the list, form PTO-1449, or PTO/SB/08A and 08B, submitted, e.g., by crossing out the listing of the cumulative information. But see *Semiconductor Energy Laboratory Co. v. Samsung Electronics Co.*, 204 F.3d 1368, 1374, 54 USPQ2d 1001, 1005 (Fed. Cir. 2000) (Reference was not cumulative since it contained a more complete combination of the claimed elements than any other reference before the examiner. "A withheld reference may be highly material when it discloses a more complete combination of relevant features, even if those features are before the patent examiner in other references." (citations omitted)).

37 CFR 1.98(a)(3)(ii) states that if a written English language translation of a non-English language document, or portion thereof, is within the possession, custody or control of, or is readily available to any individual designated in 37 CFR 1.56(c), a copy of the translation shall accompany the statement. Translations are not required to be filed unless they have been reduced to writing and are actually translations of what is contained in the non-English language information. If no translation is submitted, the examiner will consider the information in view of the concise explanation and insofar as it is understood on its face, e.g., drawings, chemical formulas, English language abstracts, in the same manner that non-English language information in Office search files is considered by examiners in conducting searches.

### **A (3) Concise Explanation of Relevance for Non-English Language Information**

Each information disclosure statement must further include a concise explanation of the relevance, as it is presently understood by the individual designated in

37 CFR 1.56(c) most knowledgeable about the content of the information listed that is not in the English language. The concise explanation may be either separate from the specification or incorporated therein with the page(s) and lines of the specification where it is incorporated being noted in the IDS.

The requirement for a concise explanation of relevance is limited to information that is not in the English language. The explanation required is limited to the relevance as understood by the individual designated in 37 CFR 1.56(c) most knowledgeable about the content of the information at the time the information is submitted to the Office. If a complete translation of the information into English is submitted with the non-English language information, no concise explanation is required. An English-language equivalent application may be submitted to fulfill this requirement if it is, in fact, a translation of a foreign language application being listed in an information disclosure statement. There is no requirement for the translation to be verified. Submission of an English language abstract of a reference may fulfill the requirement for a concise explanation. Where the information listed is not in the English language, but was cited in a search report or other action by a foreign patent office in a counterpart foreign application, the requirement for a concise explanation of relevance can be satisfied by submitting an English-language version of the search report or action which indicates the degree of relevance found by the foreign office. This may be an explanation of which portion of the reference is particularly relevant, to which claims it applies, or merely an "X", "Y", or "A" indication on a search report. The requirement for a concise explanation of non-English language information would not be satisfied by a statement that a reference was cited in the prosecution of a United States application which is not relied on under 35 U.S.C. 120.

If information cited or submitted in a prior application relied on under 35 U.S.C. 120 was not in English, a concise explanation of the relevance of the information to the new application is not required unless the relevance of the information differs from its relevance as explained in the prior application.

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The concise explanation may indicate that a particular figure or paragraph of the patent or publication is relevant to the claimed invention. It might be a simple statement pointing to similarities between the item of information and the claimed invention. It is permissible but not necessary to discuss differences between the cited information and the claims. However, see *Semiconductor Energy Laboratory Co. v. Samsung Electronics Co.*, 204 F.3d 1368, 1376, 54 USPQ2d 1001, 1007 (Fed. Cir. 2000) (“[A]lthough MPEP Section 609A(3) allows the applicant some discretion in the manner in which it phrases its concise explanation, it nowhere authorizes the applicant to intentionally omit altogether key teachings of the reference.”).

In *Semiconductor Energy Laboratory*, patentee during prosecution submitted an untranslated 29-page Japanese reference as well as a concise explanation of its relevance and an existing one-page partial English translation, both of which were directed to less material portions of the reference. The untranslated portions of the Japanese reference “contained a more complete combination of the elements claimed [in the patent] than anything else before the PTO.” 204 F.3d at 1376, 54 USPQ2d at 1005. The patentee, whose native language was Japanese, was held to have understood the materiality of the reference. “The duty of candor does not require that the applicant translate every foreign reference, but only that the applicant refrain from submitting partial translations and concise explanations that it knows will misdirect the examiner’s attention from the reference’s relevant teaching.” 204 F.3d at 1378, 54 USPQ2d at 1008.

Although a concise explanation of the relevance of the information is not required for English language information, applicants are encouraged to provide a concise explanation of why the English-language information is being submitted and how it is understood to be relevant. Concise explanations (especially those which point out the relevant pages and lines) are helpful to the Office, particularly where documents are lengthy and complex and applicant is aware of a section that is highly relevant to patentability or

where a large number of documents are submitted and applicant is aware that one or more are highly relevant to patentability.

**B. Time for Filing**

The procedures and requirements under 37 CFR 1.97 for submitting an information disclosure statement are linked to four stages in the processing of a patent application:

(1)(a) for national applications (not including CPAs), within 3 months of filing, or before the mailing of a first Office action on the merits, whichever is later;

(b) for international applications, within 3 months of the date of entry of the national stage as set forth in 37 CFR 1.491 or before the mailing of a first Office action on the merits in the national stage application, whichever is later;

(c) for continued examinations (i.e., RCEs filed under 37 CFR 1.114) and CPAs filed under 37 CFR 1.53(d), before the mailing of a first Office action on the merits;

(2) after the period in (1), but prior to the prosecution of the application closes, i.e., before the mailing of a final Office action, a Notice of Allowance, or an *Ex parte Quayle* action, whichever is earlier;

(3) after the period in (2) but on or before the date the issue fee is paid; and

(4) after the period in (3) and up to the time the patent application can be effectively withdrawn from issue under 37 CFR 1.313(c).

These procedures and requirements apply to applications filed under 35 U.S.C. 111(a) (utility), 161 (plants), 171 (designs), and 251 (reissue), as well as international applications entering the national stage under 35 U.S.C. 371.

The requirements based on the time when the information disclosure statement is filed are summarized as follows.

<u>Time when IDS is filed</u>	<u>37 CFR 1.97 Requirements</u>
(1)(a) for national applications (not including CPAs), within 3 months of filing or before first Office action on the merits, whichever is later; (b) for national stage applications, within 3 months of entry into national stage or before first Office action on the merits, whichever is later;	None (IDS will be considered).
(c) for RCEs and CPAs before the first Office action on the merits.	
(2) After (1) but before final action, notice of allowance, or <i>Quayle</i> action.	1.97(e) statement or 1.17(p) fee.
(3) After (2) and before (or with) payment of issue fee.	1.97(e) statement, and 1.17(p) fee.
(4) After payment of issue fee.	IDS will not be considered. (See petition under 37 CFR 1.313(c) to withdraw from issue.)

**B (1) Information Disclosure Statement Filed BEFORE First Action on the Merits or Within Three (3) Months of Actual Filing Date (37 CFR 1.97(b))**

An information disclosure statement will be considered by the examiner if filed within any one of the following time periods:

(A) for national applications (not including CPAs), within 3 months of the filing date of the national application or before the mailing date of a first Office action on the merits;

(B) for international applications, within 3 months of the date of entry of the national stage as set forth in 37 CFR 1.491 or before the mailing date of a first Office action on the merits; or

(C) for RCEs and CPAs, before the mailing date of a first Office action on the merits.

An information disclosure statement filed within one of these periods requires neither a fee nor a statement under 37 CFR 1.97(e). An information disclosure statement will be considered to have been filed on the day it was received in the Office, or on an earlier date of mailing if accompanied by a properly executed certificate of mailing or facsimile transmission under 37 CFR 1.8, or if it is in compliance with the provisions of "Express Mail" delivery under 37 CFR 1.10. An Office action is mailed on the date indicated in the Office action.

It would not be proper to make final a first Office action in a continuing application or in an application after the filing of a RCE if the information submitted in the IDS during the time period set forth in 37 CFR 1.97(b) is used in a new ground of rejection.

**(a) National or International Applications**

The term "national application" includes continuing applications (continuations, divisions, and continuations-in-part but not CPAs), so 3 months will be measured from the actual filing date of an application as opposed to the effective filing date of a continuing application. For international applications, the 3 months will be measured from the date of entry of the national stage.

All information disclosure statements that comply with the content requirements of 37 CFR 1.98 and are filed within 3 months of the filing date, will be considered by the examiner, regardless of whatever else has occurred in the examination process up to that point in time. Thus, in the rare instance that a final Office action, a notice of allowance, or an *Ex parte Quayle* action is mailed prior to a date which is 3 months from the filing date, any information contained in a complete information disclosure statement filed within that 3-month window will be considered by the examiner.

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Likewise, an information disclosure statement will be considered if it is filed later than 3 months after the application filing date but before the mailing date of a first Office action on the merits. An action on the merits means an action which treats the patentability of the claims in an application, as opposed to only formal or procedural requirements. An action on the merits would, for example, contain a rejection or indication of allowability of a claim or claims rather than just a restriction requirement (37 CFR 1.142) or just a requirement for additional fees to have a claim considered (37 CFR 1.16(d)). Thus, if an application was filed on January 2 and the first Office action on the merits was not mailed until 6 months later on July 2, the examiner would be required to consider any proper information disclosure statement filed prior to July 2.

**(b) RCE and CPA**

The 3-month window as discussed above does not apply to a RCE filed under 37 CFR 1.114 or a CPA filed under 37 CFR 1.53(d). An IDS filed after the filing of a RCE will be considered if the IDS is filed before the mailing date of a first Office action on the merits. A RCE is not the filing of an application, but merely the continuation of prosecution in the current application. After the mailing of a RCE, such application is treated as an amended application by the examiner and is subject to a short turnover time. Therefore, applicants are encouraged to file any IDS with the filing of a RCE. See MPEP § 706.07(h) for details on RCEs.

Similarly, an IDS filed in a CPA will be considered if the IDS is filed before the mailing date of a first Office action on the merits. Applicants are encouraged to file any IDS in a CPA as early as possible, preferably at the time of filing of the CPA request.

If an IDS cannot be filed before the mailing of a first Office action on the merits (generally within 2 months from the filing of the RCE or CPA), applicants may request a 3-month suspension of action under 37 CFR 1.103(c) in an application at the time of filing of the RCE, or under 37 CFR 1.103(b) in a CPA, at the time of filing of the CPA. Where an IDS is mailed to the Office shortly before the expiration of a 3-month suspension under 37 CFR 1.103(b) or (c),

applicant is requested to make a courtesy call to notify the examiner as to the IDS submission.

**B (2) Information Disclosure Filed After B(1) but BEFORE Mailing of Final Action, Notice of Allowance, or an Ex parte Quayle Action (37 CFR 1.97(c))**

An information disclosure statement will be considered by the examiner if filed after the period specified in subsection III.B(1) above, but prior to the date the prosecution of the application closes, i.e., before (not on the same day as the mailing date of any of the following:

- a final action under 37 CFR 1.113, e.g., final rejection;

- a notice of allowance under 37 CFR 1.311; or

- an action that closes prosecution in the application, e.g., an *Ex parte Quayle* action,

whichever occurs first, provided the information disclosure statement is accompanied by either (1) a statement as specified in 37 CFR 1.97(e) (see the discussion in subsection III.B(5) below); or (2) the fee set forth in 37 CFR 1.17(p). If a final action, notice of allowance, or an *Ex parte Quayle* action is mailed in an application and later withdrawn, the application will be considered as not having had a final action, notice of allowance, or an *Ex parte Quayle* action mailed for purposes of considering an information disclosure statement.

An *Ex parte Quayle* action is an action that closes the prosecution in the application as referred to in 37 CFR 1.97(c). Therefore, an information disclosure statement filed after an *Ex parte Quayle* action, must comply with the provisions of 37 CFR 1.97(d).

**(a) Information is Used in a New Ground of Rejection****i) Final Rejection is Not Appropriate**

If information submitted during the period set forth in 37 CFR 1.97(c) with a statement under 37 CFR 1.97(e) is used in a new ground of rejection on unamended claims, the next Office action will not be made final since in this situation it is clear that applicant has submitted the information to the Office promptly after it has become known and the information is being submitted prior to a final determination on patentability by the Office.



**ii) Final Rejection is Appropriate**

The information submitted with a statement under 37 CFR 1.97(e) can be used in a new ground of rejection and the next Office action can be made final, if the new ground of rejection was necessitated by amendment of the application by applicant. Where the information is submitted during this period with a fee as set forth in 37 CFR 1.17(p), the examiner may use the information submitted, and make the next Office action final whether or not the claims have been amended, provided that no other new ground of rejection which was not necessitated by amendment to the claims is introduced by the examiner. See MPEP § 706.07(a).

**B(3)Information Disclosure Statement Filed After B(2), but Prior to Payment of Issue Fee 37 CFR 1.97(d)**

An information disclosure statement will be considered by the examiner if filed on or after the mailing date of any of the following: a final action under 37 CFR 1.113; a notice of allowance under 37 CFR 1.311; or an action that closes prosecution in the application, e.g., an *Ex parte Quayle* action, but before or simultaneous with payment of the issue fee, provided the statement is accompanied by:

- (A) a statement as specified in 37 CFR 1.97(e) (see the discussion in subsection B(5); and
- (B) the fee set forth in 37 CFR 1.17(p).

These requirements are appropriate in view of the late stage of prosecution when the information is being submitted, i.e., after the examiner has reached a final determination on the patentability of the claims presented for examination. Payment of the fee (37 CFR 1.17(p)) and submission of the appropriate statement (37 CFR 1.97(e)) are the essential elements for having information considered at this advanced stage of prosecution, assuming the content requirements of 37 CFR 1.98 are satisfied.

Form paragraph 6.52 may be used to inform the applicant that the information disclosure statement is being considered.

**¶ 6.52 Information Disclosure Statement Filed After Prosecution Has Been Closed**

The information disclosure statement (IDS) submitted on [1] was filed after the mailing date of the [2] on [3]. The submission is in compliance with the provisions of 37 CFR 1.97. Accord-

ingly, the information disclosure statement is being considered by the examiner.

**Examiner Note:**

1. In bracket 1, insert the date the IDS was filed.
2. In bracket 2, insert --final Office action--, --Notice of Allowance--, or an --*Ex parte Quayle* action-- as appropriate.

The requirements of 37 CFR 1.97 provide for consideration by the Office of information which is submitted within a reasonable time, i.e., within 3 months after an individual designated in 37 CFR 1.56(c) becomes aware of the information or within 3 months of the information being cited in a communication from a foreign patent office in a counterpart foreign application. This undertaking by the Office to consider information would be available throughout the pendency of the application until the point where the patent issue fee was paid.

If an applicant chose not to comply, or could not comply, with the requirements of 37 CFR 1.97(d), the applicant may file a RCE under 37 CFR 1.114, or a continuing application under 37 CFR 1.53(b) or (d) to have the information considered by the examiner. If the applicant files a continuing application under 37 CFR 1.53(b), the parent application could be permitted to become abandoned by not paying the issue fee required in the Notice of Allowance. If the prior application is a design application, or a utility or plant application filed before May 29, 2000, the filing of a continued prosecution application under 37 CFR 1.53(d) automatically abandons the prior application. See the discussion in subsection I. above under the heading "IDS IN CONTINUED EXAMINATIONS AND CONTINUING APPLICATION."

**B(4)Information Disclosure Statement Filed After Payment of Issue Fee**

After the issue fee has been paid on an application, it is impractical for the Office to attempt to consider newly submitted information. Information disclosure statements filed after payment of the issue fee in an application will not be considered but will merely be placed in the application file. See subsection C below. The application may be withdrawn from issue at this point, pursuant to 37 CFR 1.313(c)(2) or 1.313(c)(3) so that the information can be considered in the application upon the filing of a RCE under 37 CFR 1.114 or in a continuing application filed under 37 CFR 1.53(b) or 1.53(d). In this situation, a RCE, or a CPA

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(if the prior application is a design application, or a utility or plant application filed before May 29, 2000), or a continuing application filed under 37 CFR 1.53(b) could be filed even though the issue fee had already been paid. See MPEP § 1308. Applicants are encouraged to file the petition under 37 CFR 1.313(c)(2) with a RCE, or the petition under 37 CFR 1.313(c)(3) with a CPA or continuing application under 37 CFR 1.53(b), by facsimile transmission to the Office of Petitions (see MPEP § 1730 for the facsimile number). The Office cannot ensure that any petition under 37 CFR 1.313(c) will be acted upon prior to the date of patent grant. Applicants considering filing a petition under 37 CFR 1.313(c) are encouraged to call the Office of Petitions to determine whether sufficient time remains before the patent issue date to consider and grant a petition under 37 CFR 1.313(c). The petition need not be accompanied by the information disclosure statement if the size of the statement makes its submission by facsimile impracticable, but the petition should indicate that an IDS will be filed in the application or in the continuing application if it does not accompany the petition under 37 CFR 1.313(c). The IDS should be filed before the mailing of a first Office action on the merits. If the IDS cannot be filed within this time period, applicants may request a three-month suspension of action under 37 CFR 1.103 at the time of filing of the RCE or CPA. See the discussion above in paragraph III.B(1)(b) above.

Alternatively, for example, a petition pursuant to 37 CFR 1.313(c)(1) could be filed if applicant states that one or more claims are unpatentable. This statement that one or more claims are unpatentable over the information must be unequivocal. A statement that a serious question as to patentability of a claim has been raised, for example, would not be acceptable to withdraw an application from issue under 37 CFR 1.313(c)(1). Form paragraph 13.09 may be used.

**¶ 13.09 Information Disclosure Statement, Issue Fee Paid**

Applicant's information disclosure statement of [1] was filed after the issue fee was paid. Information disclosure statements filed after payment of the issue fee will not be considered, but will be placed in the file. However, the application may be withdrawn from issue in order to file a request for continued examination (RCE) under 37 CFR 1.114 upon the grant of a petition under 37 CFR 1.313(c)(2), or a continuing application under 37 CFR 1.53(b) (or a continued prosecution application (CPA) under 37 CFR 1.53(d) if the prior application is a design application, or a

utility or plant application filed before May 29, 2000) upon the grant of a petition filed under the provisions of 37 CFR 1.313(c)(3). Alternatively, the other provisions of 37 CFR 1.313 may apply, e.g., a petition to withdraw the application from issue under the provisions of 37 CFR 1.313(c)(1) may be filed together with an unequivocal statement by the applicant that one or more claims are unpatentable over the information contained in the statement. The information disclosure statement would then be considered upon withdrawal of the application from issue under 37 CFR 1.313(c)(1).

**Examiner Note:**

1. For information disclosure statements submitted after the issue fee has been paid, use this form paragraph with form PTOL-90 or PTO-90C.
2. In bracket 1, insert the filing date of the IDS.

If an application has been withdrawn from issue under one of the provisions of 37 CFR 1.313(c)(1)-(3), it will be treated as though no notice of allowance had been mailed and the issue fee had not yet been paid with regard to the time for filing information disclosure statements. Petitions under 37 CFR 1.313(c) should be directed to the Office of Petitions in the Office of the Deputy Commissioner for Patent Examination Policy. See MPEP § 1308.

**B(5) Statement Under 37 CFR 1.97(e)**

A statement under 37 CFR 1.97(e) must state either

(1) that each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the statement, or

(2) that no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the statement after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the statement.

A statement under 37 CFR 1.97(e) can contain either of two statements. One statement is that each item of information in an information disclosure statement was first cited in any communication, such as a search report, from a patent office outside the U.S. in a counterpart foreign application not more than 3 months prior to the filing date of the statement.



Applicant would not be able to make a statement under 37 CFR 1.97(e) where an item of information was first cited by a foreign patent office, for example, a year before the filing of the IDS, in a communication from that foreign patent office, and the same item of information is once again cited by another foreign patent office within three months prior to the filing of the IDS in the Office. Similarly, applicant would not be able to make a statement under 37 CFR 1.97(e) where an item of information was cited in an examination report and the same item of information was previously cited more than three months prior to the filing of the IDS in the Office, in a search report from the same foreign patent office. Under this statement, it does not matter whether any individual with a duty of disclosure actually knew about any of the information cited before receiving the search report.

The date on the communication by the foreign patent office begins the 3-month period in the same manner as the mailing of an Office action starts a 3-month shortened statutory period for reply. If the communication contains two dates, the mailing date of the communication is the one which begins the 3-month period. The date which begins the 3-month period is not the date the communication was received by a foreign associate or the date it was received by a U.S. registered practitioner. Likewise, the statement will be considered to have been filed on the date the statement was received in the Office, or on an earlier date of mailing or transmission if accompanied by a properly executed certificate of mailing or facsimile transmission under 37 CFR 1.8, or if it is in compliance with the provisions for "Express Mail" delivery under 37 CFR 1.10.

The term counterpart foreign patent application means that a claim for priority has been made in either the U.S. application or a foreign application based on the other, or that the disclosures of the U.S. and foreign patent applications are substantively identical (e.g., an application filed in the European Patent Office claiming the same U.K. priority as claimed in the U.S. application).

Communications from foreign patent offices in foreign applications sometimes include a list of the family of patents corresponding to a particular patent being cited in the communication. The family of patents may include a United States patent or other patent in the English language. Some applicants submit

information disclosure statements to the PTO which list and include copies of both the particular patent cited in the foreign patent office communication and the related United States or other English language patent from the family list. Since this is to be encouraged, the United States or other English language patent will be construed as being cited by the foreign patent office for purposes of a statement under 37 CFR 1.97(e)(1). The examiner should consider the United States or other English language patent if 37 CFR 1.97 and 37 CFR 1.98 are complied with.

If an information disclosure statement includes a copy of a dated communication from a foreign patent office which clearly shows that the statement is being submitted within 3 months of the date on the communication, the copy will be accepted as the required communication. It will be assumed, in the absence of evidence to the contrary, that the communication was for a counterpart foreign application.

In the alternative, a statement can be made if no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application and, to the knowledge of the person signing the statement after making reasonable inquiry, neither was it known to any individual having a duty to disclose more than 3 months prior to the filing of the statement.

The phrase "after making reasonable inquiry" makes it clear that the individual making the statement has a duty to make reasonable inquiry regarding the facts that are being stated. The statement can be made by a registered practitioner who represents a foreign client and who relies on statements made by the foreign client as to the date the information first became known. A registered practitioner who receives information from a client without being informed whether the information was known for more than 3 months, however, cannot make the statement under 37 CFR 1.97(e)(2) without making reasonable inquiry. For example, if an inventor gave a publication to the attorney prosecuting an application with the intent that it be cited to the Office, the attorney should inquire as to when that inventor became aware of the publication and should not submit a statement under 37 CFR 1.97(e)(2) to the Office until a satisfactory response is received. The statement can

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be based on present, good faith knowledge about when information became known without a search of files being made.

A statement under 37 CFR 1.97(e) need not be in the form of an oath or a declaration under 37 CFR 1.68. A statement under 37 CFR 1.97(e) by a registered practitioner or any other individual that the statement was filed within the 3-month period of either first citation by a foreign patent office or first discovery of the information will be accepted as dispositive of compliance with this provision in the absence of evidence to the contrary. For example, a statement under 37 CFR 1.97(e) could read as follows:

I hereby state that each item of information contained in this Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than 3 months prior to the filing of this statement.,

or

I hereby state that no item of information in the Information Disclosure Statement filed herewith was cited in a communication from a foreign patent office in a counterpart foreign application, and, to my knowledge after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 CFR 1.56(c) more than 3 months prior to the filing of this Information Disclosure Statement.

An information disclosure statement may include two lists and two statements, similar to the above examples, in situations where some of the information listed was cited in a communication from a foreign patent office not more than 3 months prior to filing the statement and some was not, but was not known more than 3 months prior to filing the statement.

A copy of the foreign search report need not be submitted with the statement under 37 CFR 1.97(e), but an individual may wish to submit an English-language version of the search report to satisfy the requirement for a concise explanation where non-English language information is cited. The time at which information was known to any individual designated in 37 CFR 1.56(c) is the time when the information was discovered in association with the application even if awareness of the materiality came later. The Office wishes to encourage prompt evaluation of the relevance of information and to have a date

certain for determining if a statement under 37 CFR 1.97(e) can properly be made. A statement on information and belief would not be sufficient. Examiners should not remind or otherwise make any comment about an individual's duty of candor and good faith. Questions about the adequacy of any statement received in writing by the Office should be directed to the Office of Patent Legal Administration.

#### **B(6) Extensions of Time (37 CFR 1.97(f))**

No extensions of time for filing an information disclosure statement are permitted under 37 CFR 1.136(a) or (b). If a bona fide attempt is made to comply with the content requirements of 37 CFR 1.98, but part of the required content is inadvertently omitted, additional time may be given to enable full compliance.

#### ***C. Examiner Handling of Information Disclosure Statements***

Information disclosure statements will be reviewed for compliance with the requirements of 37 CFR 1.97 and 37 CFR 1.98 as discussed in subsection III.A and B above. Applicant will be notified of compliance and noncompliance with the rules as discussed below.

#### **C(1) Noncomplying Information Disclosure Statements**

Pursuant to 37 CFR 1.97(i), submitted information, filed before the grant of a patent, which does not comply with 37 CFR 1.97 and 37 CFR 1.98 will be placed in the file, but will not be considered by the Office. Information submitted after the grant of a patent must comply with 37 CFR 1.501.

If an information disclosure statement does not comply with the requirements based on the time of filing of the IDS as discussed in subsection III.B above, including the requirements for fees and/or statement under 37 CFR 1.97(e), the IDS will be placed in the application file, but none of the information will be considered by the examiner. The examiner may use form paragraph 6.49 which is reproduced below to inform applicant that the information has not been considered. Applicant may then file a new information disclosure statement or correct the deficiency in the previously filed IDS, but the date that the new IDS or correction is filed will be the date of the IDS for purposes of determining compliance with the

requirements based on the time of filing of the IDS (37 CFR 1.97).

The examiner should write "not considered" on an information disclosure statement where none of the information listed complies with the requirements, e.g., no copies of listed items submitted. If none of the information listed on a PTO-1449 or PTO/SB/08A and 08B form is considered, a diagonal line should also be drawn in pencil across the form and the form placed on the right side of the application file to instruct the printer not to list the information on the face of the patent if the application goes to issue. The paper containing the disclosure statement or list will be placed in the record in the application file. The examiner will inform applicant that the information has not been considered and the reasons why by using form paragraphs 6.49 through 6.49.09. If the improper citation appears as part of another paper, e.g., an amendment, which may be properly entered and considered, the portion of the paper which is proper for consideration will be considered.

If an item of information in an IDS fails to comply with all the requirements of 37 CFR 1.97 and 37 CFR 1.98, that item of information in the IDS will not be considered and a line should be drawn through the citation to show that it has not been considered. However, other items of information that do comply with all the requirements of 37 CFR 1.97 and 37 CFR 1.98 will be considered by the examiner.

If information listed in the specification rather than in a separate paper, or if the other content requirements as discussed in subsection III.A above are not complied with, the information need not be considered by the examiner, in which case, the examiner should notify applicant in the next Office action that the information has not been considered.

#### (a) Form Paragraphs

##### ¶ 6.49 Information Disclosure Statement Not Considered

The information disclosure statement filed [1] fails to comply with the provisions of 37 CFR 1.97, 1.98 and MPEP § 609 because [2]. It has been placed in the application file, but the information referred to therein has not been considered as to the merits. Applicant is advised that the date of any resubmission of any item of information contained in this information disclosure statement or the submission of any missing element(s) will be the date of submission for purposes of determining compliance with the requirements based on the time of filing the statement, including all requirements for statements under 37 CFR 1.97(e). See MPEP § 609 subsection III, C(1).

#### Examiner Note:

See MPEP § 609 for situations where the use of this form paragraph would be appropriate.

##### ¶ 6.49.01 Information Disclosure Statement Not Considered, After First Action, But Before the Prosecution of the Application Closes, No Statement

The information disclosure statement filed [1] fails to comply with 37 CFR 1.97(c) because it lacks a statement as specified in 37 CFR 1.97(e). It has been placed in the application file, but the information referred to therein has not been considered.

##### ¶ 6.49.02 Information Disclosure Statement Not Considered, After First Action, But Before the Prosecution of the Application Closes, No Fee

The information disclosure statement filed [1] fails to comply with 37 CFR 1.97(c) because it lacks the fee set forth in 37 CFR 1.17(p). It has been placed in the application file, but the information referred to therein has not been considered.

##### ¶ 6.49.03 Information Disclosure Statement Not Considered, After the Prosecution of the Application Closes, Issue Fee Not Paid, No Statement

The information disclosure statement filed [1] fails to comply with 37 CFR 1.97(d) because it lacks a statement as specified in 37 CFR 1.97(e). It has been placed in the application file, but the information referred to therein has not been considered.

##### ¶ 6.49.05 Information Disclosure Statement Not Considered, After the Prosecution of the Application Closes, Issue Fee Not Paid, No Fee

The information disclosure statement filed [1] fails to comply with 37 CFR 1.97(d) because it lacks the fee set forth in 37 CFR 1.17(p). It has been placed in the application file, but the information referred to therein has not been considered.

##### ¶ 6.49.06 Information Disclosure Statement Not Considered, References Listed in Specification

The listing of references in the specification is not a proper information disclosure statement. 37 CFR 1.98(b) requires a list of all patents, publications, applications, or other information submitted for consideration by the Office, and MPEP § 609 subsection III A(1) states, "the list may not be incorporated into the specification but must be submitted in a separate paper." Therefore, unless the references have been cited by the examiner on form PTO-892, they have not been considered.

##### ¶ 6.49.07 Information Disclosure Statement Not Considered, No Copy of References

The information disclosure statement filed [1] fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each U.S. and foreign patent; each publication or that portion which caused it to be listed; for each cited pending U.S. application, the application specification including the claims, and any drawing of the application, or that portion of the application which caused it to be listed including any claims directed to that portion and all other information or that portion which caused it to be listed. It



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has been placed in the application file, but the information referred to therein has not been considered.

**¶ 6.49.08 Information Disclosure Statement Not Considered, No List of References**

The information disclosure statement filed [1] fails to comply with 37 CFR 1.98(a)(1), which requires a list of all patents, publications, applications, or other information submitted for consideration by the Office. It has been placed in the application file, but the information referred to therein has not been considered.

**¶ 6.49.09 Information Disclosure Statement Not Considered, No Explanation of Relevance of Non-English Language Information**

The information disclosure statement filed [1] fails to comply with 37 CFR 1.98(a)(3)(i) because it does not include a concise explanation of the relevance, as it is presently understood by the individual designated in 37 CFR 1.56(c) most knowledgeable about the content of the information, of each reference listed that is not in the English language. It has been placed in the application file, but the information referred to therein has not been considered.

**¶ 6.51 Time for Completing Information Disclosure Statement**

The information disclosure statement filed on [1] does not fully comply with the requirements of 37 CFR 1.98 because: [2]. Since the submission appears to be *bona fide*, applicant is given **ONE (1) MONTH** from the date of this notice to supply the above-mentioned omissions or corrections in the information disclosure statement. **NO EXTENSION OF THIS TIME LIMIT MAY BE GRANTED UNDER EITHER 37 CFR 1.136(a) OR (b).** Failure to timely comply with this notice will result in the above-mentioned information disclosure statement being placed in the application file with the non-complying information not being considered. See 37 CFR 1.97(i).

**Examiner Note:**

Use this form paragraph if an IDS complies with the timing requirements of 37 CFR 1.97 but part of the content requirements of 37 CFR 1.98 has been inadvertently omitted.

This practice does not apply where there has been a deliberate omission of some necessary part of an Information Disclosure Statement or where the requirements based on the time of filing the statement, as set forth in 37 CFR 1.97, have not been complied with.

**C(2)Complying Information Disclosure Statements**

The information contained in information disclosure statements which comply with both the content requirements of 37 CFR 1.98 and the requirements, based on the time of filing the statement, of 37 CFR 1.97 will be considered by the examiner. Consideration by the examiner of the information submitted in an IDS means that the examiner will consider the documents in the same manner as other documents in

Office search files are considered by the examiner while conducting a search of the prior art in a proper field of search. The initials of the examiner placed adjacent to the citations on the PTO-1449 or PTO/SB/08A and 08B or its equivalent mean that the information has been considered by the examiner to the extent noted above. Only where the relevancy of the information is actually discussed in the application file (either by the examiner or by the applicant) or where the information is relied upon to reject a claim in the application, will the information deemed to be "considered" (to the extent discussed) for the purposes of reexamination under the *Portola* guidelines. See MPEP § 2242 under the subsection "General Principles Governing Compliance With Portola Packaging."

Examiners must consider all citations submitted in conformance with the rules and this section, and their initials when placed adjacent to the considered citations on the list or in the boxes provided on a form PTO-1449 or PTO/SB/08A and 08B provides a clear record of which citations have been considered by the Office. The examiner must also fill in his or her name and the date the information was considered in blocks at the bottom of the PTO-1449 or PTO/SB/08A and 08B form. If the citations are submitted on a list other than on a form PTO-1449 or PTO/SB/08A and 08B, the examiner may write "all considered" and his or her initials to indicate that all citations have been considered. If any of the citations are considered, a copy of the submitted list, form PTO-1449, or PTO/SB/08A and 08B, as reviewed by the examiner, will be returned to the applicant with the next communication. Those citations not considered by the examiner will have a line drawn through the citation and any citations considered will have the examiner's initials adjacent thereto. The original copy of the list, form PTO-1449, or PTO/SB/08A and 08B will be entered into the application file. The copy returned to applicant will serve both as acknowledgement of receipt of the information disclosure statement and as an indication as to which references were considered by the examiner. Forms PTO-326 and PTOL-37 include a box to indicate the attachment of form PTO-1449 or PTO/SB/08A and 08B.

Information which complies with requirements as discussed in this section but which is in a non-English language will be considered in view of the concise explanation submitted (subsection III.A(3) above) and

insofar as it is understood on its face, e.g., drawings, chemical formulas, in the same manner that non-English language information in Office search files is considered by examiners in conducting searches. The examiner need not have the information translated unless it appears to be necessary to do so. The examiner will indicate that the non-English language information has been considered in the same manner as consideration is indicated for information submitted in English. The examiner should not require that a translation be filed by applicant. The examiner should not make any comment such as that the non-English language information has only been considered to the extent understood, since this fact is inherent. See *Semiconductor Energy Laboratory Co. v. Samsung Electronics Co.*, 204 F.3d 1368, 1377-78, 54 USPQ2d 1001, 1008 (Fed. Cir. 2000) (“[A]s MPEP Section 609C(2) reveals, the examiner’s understanding of a foreign reference is generally limited to that which he or she can glean from the applicant’s concise statement...Consequently, while the examiner’s initials require that we presume that he or she considered the [foreign] reference, this presumption extends only to the examiner’s consideration of the brief translated portion and the concise statement.”).

Since information is required to be submitted in a separate paper listing the citations rather than in the specification, there is no need to mark “All checked” or “Checked” in the margin of a specification containing citations.

If an item of information in an IDS fails to comply with requirements of 37 CFR 1.97 and 37 CFR 1.98, a line should be drawn through the citation to show that it has not been considered. The other items of information listed that do comply with the requirements of 37 CFR 1.97 and 37 CFR 1.98 will be considered by the examiner and will be appropriately initialed.

### **C (3) Documents Submitted As Part of Applicant’s Reply to Office Action**

Occasionally, documents are submitted and relied on by an applicant when replying to an Office action. These documents may be relied on by an applicant, for example, to show that an element recited in the claim is operative or that a term used in the claim has a recognized meaning in the art. Documents may be in any form but are typically in the form of an affidavit, declaration, patent, or printed publication.

To the extent that a document is submitted as evidence directed to an issue of patentability raised in an Office action, and the evidence is timely presented, applicant need not satisfy the requirements of 37 CFR 1.97 and 37 CFR 1.98 in order to have the examiner consider the information contained in the document relied on by applicant. In other words, compliance with the information disclosure rules is not a threshold requirement to have information considered when submitted by applicant to support an argument being made in a reply to an Office action.

At the same time, the document supplied and relied on by applicant as evidence need not be processed as an item of information that was cited in an information disclosure statement. The record should reflect whether the evidence was considered, but listing on a form (e.g., PTO-892, PTO-1449, or PTO/SB/08A and 08B) and appropriate marking of the form by the examiner is not required.

For example, if applicant submits and relies on three patents as evidence in reply to the first Office action and also lists those patents on a PTO-1449 or PTO/SB/08A and 08B along with two journal articles, but does not file a statement under 37 CFR 1.97(e) or the fee set forth in 37 CFR 1.17(p), it would be appropriate for the examiner to indicate that the teachings relied on by applicant in the three patents have been considered, but to line through the citation of all five documents on the PTO-1449 or PTO/SB/08A and 08B and to inform applicant that the information disclosure statement did not comply with 37 CFR 1.97(c).

### ***D. Information Printed on Patent***

A citation listed on form PTO-1449 or PTO/SB/08A and 08B and considered by the examiner in accordance with this section will be printed on the patent. A citation listed in a separate paper, equivalent to but not on form PTO-1449 or PTO/SB/08A and 08B, and considered by the examiner in accordance with this section will be printed on the patent if the list is on a separate sheet which is clearly identified as an information disclosure statement and the list lends itself to easy capture of the necessary information by the Office printing contractor, i.e., each item of information is listed on a single line, the lines are at least double-spaced from each other, the information is uniform in format for each listed item, and the list includes a column for the examiner’s initials to

## PARTS, FORM, AND CONTENT OF APPLICATION

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indicate that the information was considered. For patents printed after January 1, 2001, citations from information disclosure statements that are printed on the face of the patent will be distinguished from citations cited by the examiner on a form PTO-892. The citations cited by the examiner on a form PTO-892 will be marked with an asterisk. If an item of information is cited more than once in an IDS and on a form PTO-892, the citation of the item will be listed only once on the patent as a citation cited by the examiner.

If the applicant does not provide classification information for a citation, or if the examiner lines through incorrect classification data, the citation will be printed on the face of the patent without the classi-

fication information. If a U.S. patent application number is listed on a PTO-1449 or PTO/SB/08A and 08B form or its equivalent and the examiner considers the information and initials the form, the application number will be printed on the patent. Applicants may wish to list U.S. patent application numbers on other than a form PTO-1449 or PTO/SB/08A and 08B format to avoid the application numbers of pending applications being published on the patent. If a citation is not printed on the patent but has been considered by the examiner in accordance with this section, the patented file will reflect that fact as noted in subsection III.C(2) above.



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## MANUAL OF PATENT EXAMINING PROCEDURE

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## PARTS, FORM, AND CONTENT OF APPLICATION

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Please type a plus sign (+) inside this box ➡ +

PTQ/SS/D&A (15-96)  
Approved for use through 10/31/99. CMB 0661-0031  
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE  
are required to respond to a collection of information unless it contains

Substitute for form 1442A-PTO <b>INFORMATION DISCLOSURE          STATEMENT BY APPLICANT</b> <i>(use as many sheets as necessary)</i>			<b>Complete if Known</b>	
			<b>Application Number</b>	07/123,456
			<b>Filing Date</b>	1-2-91
			<b>First Named Inventor</b>	C. Benson
			<b>Group Art Unit</b>	3615
			<b>Examiner Name</b>	John Doe
			<b>Attorney Docket Number</b>	32210
<b>Sheet</b>		<b>of</b>		

[illegible]

FOREIGN PATENT DOCUMENTS							
Examiner Initials*	Cite No.†	Foreign Patent Document		Name of Patentee or Applicant of Cited Document	Date of Publication of Cited Document MM-DD-YYYY	Pages, Columns, Lines, Where Relevant Paragraphs or Relevant Figures Appear	Type of Document
		Office‡	Number‡				
		FR	338540		06-75		
J.D.		DE	1137729		06-65		X
J.D.		EP	9141		08-79		
J.D.		WO	80/01871		09-80		
J.D.		JP	50-3106		11-79		

Examiner Signature	John. Doe	Date Considered	Sep. 30, 1991
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\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

<sup>1</sup> Unique citation designation number. <sup>2</sup> See attached *Kind of U.S. Patent Documents* Appendix. <sup>3</sup> *Enri* is the Japanese word for "Emperor." The Japanese Patent Office that issued the document, by the two-letter code (WIPO Standard BT.3). <sup>4</sup> For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. <sup>5</sup> Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. <sup>6</sup> Applicant is to place a check mark here if English language Translation is attached.

**Burden Hour Statement:** This form is estimated to take 2.0 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be referred to the Information Officer, Patent and Trademark Office, Washington, DC 20231. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.**

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## MANUAL OF PATENT EXAMINING PROCEDURE

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PTC/SB/045 (10-50)

Approved for use through 10/31/96. OMB 0551-0031  
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE  
are required to respond to a collection of information unless it contains

Substitute for form 1449B/PTO <b>INFORMATION DISCLOSURE STATEMENT BY APPLICANT</b> <i>(Use as many sheets as necessary)</i>			<b>Complete if Known</b>	
			Application Number	07/123,456
			Filing Date	1-2-91
			First Named Inventor	C. Benson
			Group Art Unit	3615
			Examiner Name	John Doe
			Attorney Docket Number	32210
Sheet		of		

[illegible]

Examiner Signature	John Doe	Date Considered	Sept. 30, 1991
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\*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 808. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

<sup>1</sup> Unique citation designation number. <sup>2</sup> Applicant is to place a check mark here if English language Translation is attached.

Burden Hour Statement: This form is estimated to take 2.0 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.**



## Chapter 2000 Duty of Disclosure

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- 2001 Duty of Disclosure, Candor, and Good Faith
  - 2001.01 Who Has Duty To Disclose
  - 2001.03 To Whom Duty of Disclosure Is Owed
  - 2001.04 Information Under 37 CFR 1.56(a)
  - 2001.05 Materiality Under 37 CFR 1.56(b)
  - 2001.06 Sources of Information
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  - 2002.02 Must be in Writing
- 2003 Disclosure — When Made
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- 2004 Aids to Compliance With Duty of Disclosure
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  - 2012.01 Collateral Estoppel
- 2013 Protests Involving Issues of Fraud, Inequitable Conduct, and/or Violation of Duty of Disclosure
- 2014 Duty of Disclosure in Reexamination Proceedings
- 2016 Fraud, Inequitable Conduct, or Violation of Duty of Disclosure Affects All Claims
- 2022.05 Determination of "Error Without Any Deceptive Intention"

### 2000.01 Introduction

This Chapter deals with the duties owed toward the U.S. Patent and Trademark Office by the inventor and every other individual who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor or the inventor's assignee. These duties, of candor and good faith and disclosure, have been codified in 37 CFR 1.56, as promulgated pursuant to carrying out the duties of the Commissioner under Sections 2, 3, 131, and 132 of Title 35 of the United States Code.

### 2001 Duty of Disclosure, Candor, and Good Faith

*37 CFR 1.56. Duty to disclose information material to patentability.*

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

## 2001.01

## MANUAL OF PATENT EXAMINING PROCEDURE

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

37 CFR 1.56 defines the duty to disclose information to the Office.

**2001.01 Who Has Duty To Disclose**

*37 CFR 1.56. Duty to disclose information material to patentability.*

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(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

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Individuals having a duty of disclosure are limited to those who are "substantively involved in the preparation or prosecution of the application." This is intended to make clear that the duty does not extend to typists, clerks, and similar personnel who assist with an application.

The word "with" appears before "the assignee" and "anyone to whom there is an obligation to assign" to make clear that the duty applies only to individuals, not to organizations. For instance, the duty of disclosure would not apply to a corporation or institution as such. However, it would apply to individuals within the corporation or institution who were substantively involved in the preparation or prosecution of the application, and actions by such individuals may affect the rights of the corporation or institution.

**2001.03 To Whom Duty of Disclosure Is Owed**

37 CFR 1.56(a) states that the "duty of candor and good faith" is owed "in dealing with the Office" and that all associated with the filing and prosecution of a patent application have a "duty to disclose to the Office" material information. This duty "in dealing with" and "to" the Office extends, of course, to all dealings which such individuals have with the Office, and is not limited to representations to or dealings with the examiner. For example, the duty would extend to proceedings before the Board of Patent Appeals and Interferences and the Office of the Assistant Commissioner for Patents.

**2001.04 Information Under 37 CFR 1.56(a)**

*37 CFR 1.56. Duty to disclose information material to patentability.*

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) Prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

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## DUTY OF DISCLOSURE

2001.04

The language of 37 CFR 1.56 (and 37 CFR 1.555) has been modified effective March 16, 1992 to emphasize that there is a duty of candor and good faith which is broader than the duty to disclose material information. 37 CFR 1.56 further states that "no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct."

The Office strives to issue valid patents. The Office has both an obligation not to unjustly issue patents and an obligation not to unjustly deny patents. Innovation and technological advancement are best served when an inventor is issued a patent with the scope of protection that is deserved. The rules as adopted serve to remind individuals associated with the preparation and prosecution of patent applications of their duty of candor and good faith in their dealings with the Office, and will aid the Office in receiving, in a timely manner, the information it needs to carry out effective and efficient examination of patent applications.

The amendment to 37 CFR 1.56 was proposed to address criticism concerning a perceived lack of certainty in the materiality standard. The rule as promulgated will provide greater clarity and hopefully minimize the burden of litigation on the question of inequitable conduct before the Office, while providing the Office with the information necessary for effective and efficient examination of patent applications. 37 CFR 1.56 has been amended to present a clearer and more objective definition of what information the Office considers material to patentability. The rules do not define fraud or inequitable conduct which have elements both of materiality and of intent.

The definition of materiality in 37 CFR 1.56 does not impose substantial new burdens on applicants, but is intended to provide the Office with the information it needs to make a proper and independent determination on patentability. It is the patent examiner who should make the determination after considering all the facts involved in the particular case.

37 CFR 1.56 states that each individual associated with the filing and prosecution of a patent application has a duty to disclose all information known to that individual to be material to patentability as defined in the section. Thus, the duty applies to contemporaneously or presently known information. The fact that information was known years ago does not mean that

it was recognized that the information is material to the present application.

The term "information" as used in 37 CFR 1.56 means all of the kinds of information required to be disclosed and includes any information which is "material to patentability." Materiality is defined in 37 CFR 1.56(b) and discussed herein at MPEP § 2001.05. In addition to prior art such as patents and publications, 37 CFR 1.56 includes, for example, information on possible prior public uses, sales, offers to sell, derived knowledge, prior invention by another, inventorship conflicts, and the like.

The term "information" is intended to be all encompassing, similar to the scope of the term as discussed with respect to 37 CFR 1.291(a) (see MPEP § 1901.02). 37 CFR 1.56(a) also states: "The Office encourages applicants to carefully examine: (1) prior art cited in search reports of a foreign patent office in a counterpart application, and (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office." The sentence does not create any new duty for applicants, but is placed in the text of the rule as helpful guidance to individuals who file and prosecute patent applications.

It should be noted that the rules are *not* intended to require information *favorable* to patentability such as, for example, evidence of commercial success of the invention. Similarly, the rules are not intended to require, for example, disclosure of information concerning the level of skill in the art for purposes of determining obviousness.

37 CFR 1.56(a) states that the duty to disclose information exists until the application becomes abandoned. The duty to disclose information, however, does not end when an application becomes allowed but extends until a patent is granted on that application. The rules provide for information being considered after a notice of allowance is mailed and before the issue fee is paid (37 CFR 1.97(d)) (see MPEP § 609, paragraph B(3)). The rules also provide for an application to be withdrawn from issue

(A) because one or more claims are unpatentable (37 CFR 1.313(c)(1));

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## MANUAL OF PATENT EXAMINING PROCEDURE

(B) for express abandonment so that information may be considered in a continuing application before a patent issues (37 CFR 1.313(c)(3)); or

(C) for consideration of a request for continued examination (RCE) under 37 CFR 1.114 (37 CFR 1.313(a) and (c)(2)). Note that RCE practice does not apply to utility or plant applications filed before June 8, 1995 or to design applications. See MPEP § 706.07(h).

See MPEP § 1308 for additional information pertaining to withdrawal of an application from issue.

In a continuation-in-part application, individuals covered by 37 CFR 1.56 have a duty to disclose to the Office all information known to be material to patentability which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application. See 37 CFR 1.56(e).

37 CFR 1.56 provides that the duty of disclosure can be met by submitting information to the Office in the manner prescribed by 37 CFR 1.97 and 1.98. See MPEP § 609. Applicants are provided certainty as to when information will be considered, and applicants will be informed when information is not considered. Note, however, that the Office may order or conduct reexamination proceedings based on prior art that was cited but whose relevance to patentability of the claims was not discussed in any prior related Office proceeding. See MPEP § 2242.

The Office does not believe that courts should, or will, find violations of the duty of disclosure because of unintentional noncompliance with 37 CFR 1.97 and 1.98. If the noncompliance is intentional, however, the applicant will have assumed the risk that the failure to submit the information in a manner that will result in its being considered by the examiner may be held to be a violation.

The Office does not anticipate any significant change in the quantity of information cited to the Office. Presumably, applicants will continue to submit information for consideration by the Office in applications rather than making and relying on their own determinations of materiality. An incentive remains to submit the information to the Office because it will result in a strengthened patent and will avoid later questions of materiality and intent to deceive. In addition, the new rules will actually facilitate the filing of

information since the burden of submitting information to the Office has been reduced by eliminating, in most cases, the requirement for a concise statement of the relevance of each item of information listed in an information disclosure statement. It should also be noted that 37 CFR 1.97(h) states that the filing of an information disclosure statement shall not be considered to be an admission that the information cited in the statement is, or is considered to be, material to patentability as defined in 37 CFR 1.56.

## 2001.05 Materiality Under 37 CFR 1.56(b)

*37 CFR 1.56. Duty to disclose information material to patent ability.*

\*\*\*\*\*

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

\*\*\*\*\*

Under the rule, information is not material unless it comes within the definition of 37 CFR 1.56(b)(1) or (2). If information is not material, there is no duty to disclose the information to the Office. Thus, it is theoretically possible for applicants to draft claims and a specification to avoid a *prima facie* case of obviousness over a reference and then to be able to withhold the reference from the examiner. The Office believes that most applicants will wish to submit the information, however, even though they may not be required to do so, to strengthen the patent and avoid the risks of an incorrect judgment on their part on materiality or that it may be held that there was an intent to deceive the Office.

## DUTY OF DISCLOSURE

2001.06(b)

**2001.06 Sources of Information**

All individuals covered by 37 CFR 1.56 (reproduced in MPEP § 2001.01) have a duty to disclose to the U.S. Patent and Trademark Office all material information they are *aware* of regardless of the source of or how they become aware of the information. Materiality controls whether information must be disclosed to the Office, not the circumstances under which or the source from which the information is obtained. If material, the information must be disclosed to the Office. The duty to disclose material information extends to information such individuals are aware of prior to or at the time of filing the application or become aware of during the prosecution thereof.

Such individuals may be or become aware of material information from various sources such as, for example, co-workers, trade shows, communications from or with competitors, potential infringers, or other third parties, related foreign applications (see MPEP § 2001.06(a)), prior or copending United States patent applications (see MPEP § 2001.06(b)), related litigation (see MPEP § 2001.06(c)) and preliminary examination searches.

**2001.06(a) Prior Art Cited in Related Foreign Applications**

Applicants and other individuals, as set forth in 37 CFR 1.56, have a duty to bring to the attention of the Office any material prior art or other information cited or brought to their attention in any related foreign application. The inference that such prior art or other information is material is especially strong where it is the only prior art cited or where it has been used in rejecting the same or similar claims in the foreign application. See *Gemveto Jewelry Co. v. Lambert Bros., Inc.*, 542 F. Supp. 933, 216 USPQ 976 (S.D. N.Y. 1982) wherein a patent was held invalid or unenforceable because patentee's foreign counsel did not disclose to patentee's United States counsel or to the Office prior art cited by the Dutch Patent Office in connection with the patentee's corresponding Dutch application. The court stated, 542 F. Supp. at 943, 216 USPQ at 985:

Foreign patent attorneys representing applicants for U.S. patents through local correspondent firms surely must be held to the same standards of conduct which

apply to their American counterparts; a double standard of accountability would allow foreign attorneys and their clients to escape responsibility for fraud or inequitable conduct merely by withholding from the local correspondent information unfavorable to patentability and claiming ignorance of United States disclosure requirements.

**2001.06(b) Information Relating to or From Copending United States Patent Applications**

The individuals covered by 37 CFR 1.56 have a duty to bring to the attention of the examiner, or other Office official involved with the examination of a particular application, information within their knowledge as to other copending United States applications which are "material to patentability" of the application in question. As set forth by the court in *Armour & Co. v. Swift & Co.*, 466 F.2d 767, 779, 175 USPQ 70, 79 (7th Cir. 1972):

[W]e think that it is unfair to the busy examiner, no matter how diligent and well informed he may be, to assume that he retains details of every pending file in his mind when he is reviewing a particular application . . . [T]he applicant has the burden of presenting the examiner with a complete and accurate record to support the allowance of letters patent.

See also MPEP § 2004, paragraph 9.

Accordingly, the individuals covered by 37 CFR 1.56 cannot assume that the examiner of a particular application is necessarily aware of other applications which are "material to patentability" of the application in question, but must instead bring such other applications to the attention of the examiner. For example, if a particular inventor has different applications pending in which similar subject matter but patentably indistinct claims are present that fact must be disclosed to the examiner of each of the involved applications. Similarly, the prior art references from one application must be made of record in another subsequent application if such prior art references are "material to patentability" of the subsequent application.

Normally, if the application under examination is identified as a continuation or continuation-in-part of an earlier application, the examiner will consider the prior art cited in the earlier application. The examiner must indicate in the first Office action whether the prior art in a related earlier application has been

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reviewed. Accordingly, no separate citation of the same prior art need be made in the later application.

### 2001.06(c) Information From Related Litigation

Where the subject matter for which a patent is being sought is or has been involved in litigation, the existence of such litigation and any other material information arising therefrom must be brought to the attention of the U.S. Patent and Trademark Office. Examples of such material information include evidence of possible prior public use or sales, questions of inventorship, prior art, allegations of "fraud," "inequitable conduct," and "violation of duty of disclosure." Another example of such material information is any assertion that is made during litigation which is contradictory to assertions made to the examiner. *Environ Prods., Inc. v. Total Containment, Inc.*, 43 USPQ2d 1288, 1291 (E.D. Pa. 1997). Such information might arise during litigation in, for example, pleadings, admissions, discovery including interrogatories, depositions, and other documents and testimony.

Where a patent for which reissue is being sought is, or has been, involved in litigation which raised a question material to examination of the reissue application, such as the validity of the patent, or any allegation of "fraud," "inequitable conduct," or "violation of duty of disclosure," the existence of such litigation must be brought to the attention of the Office by the applicant at the time of, or shortly after, filing the application, either in the reissue oath or declaration, or in a separate paper, preferably accompanying the application, as filed. Litigation begun after filing of the reissue application should be promptly brought to the attention of the Office. The details and documents from the litigation, insofar as they are "material to patentability" of the reissue application as defined in 37 CFR 1.56, should accompany the application as filed, or be submitted as promptly thereafter as possible. See *Critikon, Inc. v. Becton Dickinson Vascular Access, Inc.*, 120 F.3d 1253, 1258, 1259, 43 USPQ2d 1666, 1670-71 (Fed. Cir. 1997) (patent held unenforceable due to inequitable conduct based on patentee's failure to disclose a relevant reference and for failing to disclose ongoing litigation).

For example, the defenses raised against validity of the patent, or charges of "fraud" or "inequitable con-

duct" in the litigation, would normally be "material to the examination" of the reissue application. It would, in most situations, be appropriate to bring such defenses to the attention of the Office by filing in the reissue application a copy of the court papers raising such defenses. At a minimum, the applicant should call the attention of the Office to the litigation, the existence and the nature of any allegations relating to validity and/or "fraud," or "inequitable conduct" relating to the original patent, and the nature of litigation materials relating to these issues. Enough information should be submitted to clearly inform the Office of the nature of these issues so that the Office can intelligently evaluate the need for asking for further materials in the litigation. See MPEP § 1442.04.

### 2001.06(d) Information Relating to Claims Copied From a Patent

Where claims are copied or substantially copied from a patent, 37 CFR 1.607(c) requires applicant shall, at the time he or she presents the claim(s), identify the patent and the numbers of the patent claims. Failure to comply with 37 CFR 1.607(c) may result in the issuance of a requirement for information as to why an identification of the source of the copied claims was not made.<sup>7</sup>

Clearly, the information required by 37 CFR 1.607(c) as to the source of copied claims is material information under 37 CFR 1.56 and failure to inform the USPTO of such information may violate the duty of disclosure.

## 2002 Disclosure — By Whom and How Made

37 CFR 1.56. Duty to disclose information material to patentability.

\*\*\*\*\*

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

\*\*\*\*\*

### 2002.01 By Whom Made

37 CFR 1.56(d) makes clear that information may be disclosed to the Office through an attorney or agent of record or through a *pro se* inventor, and that other





## DUTY OF DISCLOSURE

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individuals may satisfy their duty of disclosure to the Office by disclosing information to such an attorney, agent, or inventor who then is responsible for disclosing the same to the Office. Information that is not material need not be passed along to the Office.

**2002.02 Must be in Writing***37 CFR 1.2. Business to be transacted in writing.*

All business with the Patent and Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

*37 CFR 1.4. Nature of correspondence and signature requirements.*

\*\*\*\*\*

(b) Since each file must be complete in itself, a separate copy of every paper to be filed in a patent or trademark application, patent file, trademark registration file, or other proceeding must be furnished for each file to which the paper pertains, even though the contents of the papers filed in two or more files may be identical. The filing of duplicate copies of correspondence in the file of an application, patent, trademark registration file, or other proceeding should be avoided, except in situations in which the Office requires the filing of duplicate copies. The Office may dispose of duplicate copies of correspondence in the file of an application, patent, trademark registration file, or other proceeding.

\*\*\*\*\*

A disclosure under 37 CFR 1.56 must be in writing as prescribed by 37 CFR 1.2, and a copy of any such disclosure must be filed in each application or other proceeding to which the disclosure pertains (37 CFR 1.4(b)).

**2003 Disclosure — When Made**

In reissue applications, applicants are encouraged to file information disclosure statements at the time of filing or within 2 months of filing, since reissue applications are taken up "special" (see MPEP § 1442 and § 1442.03). However, in a reissue where waiver of the normal 2 month delay period of 37 CFR 1.176 is being requested (see MPEP § 1441), the statement should be filed at the time of filing the application, or as soon thereafter as possible.

The presumption of validity is generally strong when prior art was before and considered by the

Office and weak when it was not. See *Bolkcom v. Carborundum Co.*, 523 F.2d 492, 498, 186 USPQ 466, 471 (6th Cir. 1975).

**2003.01 Disclosure After Patent Is Granted****BY CITATIONS OF PRIOR ART UNDER 37 CFR 1.501**

Where a patentee or any member of the public (including private persons, corporate entities, and government agencies) has prior patents or printed publications which the patentee or member of the public desires to have made of record in the patent file, patentee or such member of the public may file a citation of such prior art with the U.S. Patent and Trademark Office pursuant to 37 CFR 1.501. Such citations and papers will be entered without comment by the Office. The Office does not of course consider the citation and papers but merely places them of record in the patent file. Information which may be filed under 37 CFR 1.501 is limited to prior art patents and printed publications. Any citations which include items other than patents and printed publications will not be entered in the patent file. See MPEP § 2202 through § 2208.

**BY REEXAMINATION**

Where any person, including patentee, has prior art patents and/or printed publications which said person desires to have the U.S. Patent and Trademark Office consider after a patent has issued, such person may file a request for reexamination of the patent (see 37 CFR 1.510 and MPEP § 2209 through § 2220).

**2004 Aids to Compliance With Duty of Disclosure**

While it is not appropriate to attempt to set forth procedures by which attorneys, agents, and other individuals may ensure compliance with the duty of disclosure, the items listed below are offered as examples of possible procedures which could help avoid problems with the duty of disclosure. Though compliance with these procedures may not be required, they are presented as helpful suggestions for avoiding duty of disclosure problems.



1. Many attorneys, both corporate and private, are using letters and questionnaires for applicants and others involved with the filing and prosecution of the application and checklists for themselves and applicants to ensure compliance with the duty of disclosure. The letter generally explains the duty of disclosure and what it means to the inventor and assignee. The questionnaire asks the inventor and assignee questions about

- the origin of the invention and its point of departure from what was previously known and in the prior art,
- possible public uses and sales,
- prior publication, knowledge, patents, foreign patents, etc.

The checklist is used by the attorney to ensure that the applicant has been informed of the duty of disclosure and that the attorney has inquired of and cited material prior art.

The use of these types of aids would appear to be most helpful, though not required, in identifying prior art and may well help the attorney and the client avoid or more easily explain a potentially embarrassing and harmful "fraud" allegation.

2. It is desirable to ask questions about inventorship. Who is the proper inventor? Are there disputes or possible disputes about inventorship? If there are questions, call them to the attention of the U.S. Patent and Trademark Office.

3. It is desirable to ask questions of the inventor about the disclosure of the best mode. Make sure that the best mode is described. See MPEP § 2165 - § 2165.04.

4. It is desirable for an attorney or agent to make certain that the inventor, especially a foreign inventor, recognizes his or her responsibilities in signing the oath or declaration. See 37 CFR 1.69(a).

*37 CFR 1.69. Foreign language oaths and declarations.*

(a) Whenever an individual making an oath or declaration cannot understand English, the oath or declaration must be in a language that such individual can understand and shall state that such individual understands the content of any documents to which the oath or declaration relates.

\*\*\*\*\*

Note MPEP § 602.06 for a more detailed discussion.

5. It is desirable for an attorney or agent to carefully evaluate and explain to the applicant and others involved the scope of the claims, particularly the broadest claims. Ask specific questions about possible prior art which might be material in reference to the broadest claim or claims. There is some tendency to mistakenly evaluate prior art in the light of the gist of what is regarded as the invention or narrower interpretations of the claims, rather than measuring the art against the broadest claim with all of its reasonable interpretations. It is desirable to pick out the broadest claim or claims and measure the materiality of prior art against a reasonably broad interpretation of these claims.

6. It may be useful to evaluate the materiality of prior art or other information from the viewpoint of whether it is the closest prior art or other information. This will tend to put the prior art or other information in better perspective. See *Semiconductor Energy Laboratory Co. v. Samsung Electronics Co.*, 204 F.3d 1368, 1374, 54 USPQ2d 1001, 1005 (Fed. Cir. 2000) ("A withheld reference may be highly material when it discloses a more complete combination of relevant features, even if those features are before the patent examiner in other references." (citations omitted)). However, 37 CFR 1.56 may still require the submission of prior art or other information which is not as close as that of record.

7. Care should be taken to see that prior art or other information cited in a specification or in an information disclosure statement is properly described and that the information is not incorrectly or incompletely characterized. It is particularly important for an attorney or agent to review, before filing, an application which was prepared by someone else, e.g., a foreign application. It is also important that an attorney or agent make sure that foreign clients, including foreign applicants, attorneys, and agents understand the requirements of the duty of disclosure, and that the U.S. attorney or agent review any information disclosure statements or citations to ensure that compliance with 37 CFR 1.56 is present. See *Semiconductor Energy Laboratory Co. v. Samsung Electronics Co.*, 204 F.3d 1368, 54 USPQ2d 1001 (Fed. Cir. 2000). During prosecution patentee submitted an untranslated 29-page Japanese reference as well as a concise explanation of its relevance and an existing one-page partial English translation, both of which were

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directed to less material portions of the reference. The untranslated portions of the Japanese reference "contained a more complete combination of the elements claimed [in the patent] than anything else before the PTO." 204 F.3d at 1374, 54 USPQ2d at 1005. The patentee, whose native language was Japanese, was held to have understood the materiality of the reference. "The duty of candor does not require that the applicant translate every foreign reference, but only that the applicant refrain from submitting partial translations and concise explanations that it knows will misdirect the examiner's attention from the reference's relevant teaching." 204 F.3d at 1378, 54 USPQ2d at 1008. See also *Gemveto Jewelry Co. v. Lambert Bros., Inc.*, 542 F. Supp. 933, 216 USPQ 976 (S.D.N.Y. 1982) wherein a patent was held invalid or unenforceable because patentee's foreign counsel did not disclose to patentee's United States counsel or to the Office prior art cited by the Dutch Patent Office in connection with the patentee's corresponding Dutch application. The court stated, 542 F. Supp. at 943, 216 USPQ at 985:

Foreign patent attorneys representing applicants for U.S. patents through local correspondent firms surely must be held to the same standards of conduct which apply to their American counterparts; a double standard of accountability would allow foreign attorneys and their clients to escape responsibility for fraud or inequitable conduct merely by withholding from the local correspondent information unfavorable to patentability and claiming ignorance of United States disclosure requirements.

8. Care should be taken to see that inaccurate statements or inaccurate experiments are not introduced into the specification, either inadvertently or intentionally. For example, stating that an experiment "was run" or "was conducted" when in fact the experiment was not run or conducted is a misrepresentation of the facts. No results should be represented as actual results unless they have actually been achieved. Paper examples should not be described using the past tense. See MPEP § 608.01(p) and § 707.07(l). Also, misrepresentations can occur when experiments which were run or conducted are inaccurately reported in the specification, e.g., an experiment is changed by leaving out one or more ingredients. See *Steierman v. Connelly*, 192 USPQ 433 (Bd. Pat. Int. 1975); 192 USPQ 446 (Bd. Pat. Int. 1976).

9. Do not rely on the examiner of a particular application to be aware of other applications belonging to

the same applicant or assignee. It is desirable to call such applications to the attention of the examiner even if there is only a question that they might be "material to patentability" of the application the examiner is considering. It is desirable to be particularly careful that prior art or other information in one application is cited to the examiner in other applications to which it would be material. Do not assume that an examiner will necessarily remember, when examining a particular application, other applications which the examiner is examining, or has examined. See *Armour & Co. v. Swift & Co.*, 466 F.2d 767, 779, 175 USPQ 70, 79 (7th Cir. 1972); *KangaROOS U.S.A., Inc. v. Caldor, Inc.*, 585 F. Supp. 1516, 1522, 1528-29, 222 USPQ 703, 708, 713-14 (S.D. N.Y. 1984), *vacated and remanded*, 778 F.2d 1571, 228 USPQ 32 (Fed. Cir. 1985).

While vacating the summary judgment and remanding for trial in *KangaROOS*, the Court of Appeals for the Federal Circuit stated that a "lapse on the part of the examiner does not excuse the applicant." 778 F.2d at 1576, 228 USPQ at 35.

10. When in doubt, it is desirable and safest to submit information. Even though the attorney, agent, or applicant doesn't consider it necessarily material, someone else may see it differently and embarrassing questions can be avoided. The court in *U.S. Industries v. Norton Co.*, 210 USPQ 94, 107 (N.D. N.Y. 1980) stated "In short, the question of relevancy in close cases, should be left to the examiner and not the applicant." See also *LaBounty Mfg., Inc. v. U.S. Int'l Trade Comm'n*, 958 F.2d 1066, 22 USPQ2d 1025 (Fed. Cir. 1992).

11. It may be desirable to submit information about prior uses and sales even if it appears that they may have been experimental, not involve the specifically claimed invention, or not encompass a completed invention. See *Hycor Corp. v. The Schluter Co.*, 740 F.2d 1529, 1534-37, 222 USPQ 553, 557-559 (Fed. Cir. 1984). See also *LaBounty Mfg., Inc. v. U.S. Int'l Trade Comm'n*, 958 F.2d 1066, 22 USPQ2d 1025 (Fed. Cir. 1992).

12. Submit information promptly. An applicant, attorney, or agent who is aware of prior art or other information and its significance should submit same early in prosecution, e.g., before the first action by the examiner, and not wait until after allowance. Potentially material information discovered late in the pros-

ecution should be immediately submitted. That the issue fee has been paid is no reason or excuse for failing to submit information. See *Elmwood Liquid Products, Inc. v. Singleton Packing Corp.*, 328 F. Supp. 974, 170 USPQ 398 (M.D. Fla. 1971).

13. It is desirable to avoid the submission of long lists of documents if it can be avoided. Eliminate clearly irrelevant and marginally pertinent cumulative information. If a long list is submitted, highlight those documents which have been specifically brought to applicant's attention and/or are known to be of most significance. See *Penn Yan Boats, Inc. v. Sea Lark Boats, Inc.*, 359 F. Supp. 948, 175 USPQ 260 (S.D. Fla. 1972), *aff'd*, 479 F.2d 1338, 178 USPQ 577 (5th Cir. 1973), *cert. denied*, 414 U.S. 874 (1974). But cf. *Molins PLC v. Textron Inc.*, 48 F.3d 1172, 33 USPQ2d 1823 (Fed. Cir. 1995).

14. Watch out for continuation-in-part applications where intervening material information or documents may exist; particularly watch out for foreign patents and publications related to the parent application and dated more than 1 year before the filing date of the CIP. These and other intervening documents may be material information. See *In re Ruscetta*, 255 F.2d 687, 690-91, 118 USPQ 101, 104 (CCPA 1958); *In re van Lagenhoven*, 458 F.2d 132, 173 USPQ 426 (CCPA 1972); *Chromalloy American Corp. v. Alloy Surfaces Co.*, 339 F. Supp. 859, 173 USPQ 295 (D. Del. 1972).

15. Watch out for information that might be deemed to be prior art under 35 U.S.C. 102(f) and (g).

Prior art under 35 U.S.C. 102(f) may be available under 35 U.S.C. 103. See *OddzOn Products, Inc. v. Just Toys, Inc.*, 122 F.3d 1396, 1401, 43 USPQ2d 1641, 1644 (Fed. Cir. 1997) (35 U.S.C. "102(f) is a prior art provision for purposes of § 103"); *Dale Electronics v. R.C.L. Electronics*, 488 F.2d 382, 386, 180 USPQ 225, 227 (1st Cir. 1973); and *Ex parte Andresen*, 212 USPQ 100, 102 (Bd. App. 1981).

Note also that evidence of prior invention under 35 U.S.C. 102(g) may be available under 35 U.S.C. 103, such as in *In re Bass*, 474 F.2d 1276, 177 USPQ 178 (CCPA 1973).

Note 35 U.S.C. 103(c) disqualifies 35 U.S.C. 102(f)/103 or 102(g)/103 prior art which was, at the time the second invention was made, owned by or subject to an obligation of assignment to, the person who owned the first invention. Further note that

35 U.S.C. 103(c) disqualifies 35 U.S.C. 102(e)/103 prior art for applications filed on or after November 29, 1999. See MPEP § 706.02(1) - § 706.02(1)(2).

16. Watch out for information picked up by the inventors and others at conventions, plant visits, in-house reviews, etc. See, for example, *Dale Electronics v. R.C.L. Electronics*, 488 F.2d 382, 386-87, 180 USPQ 225, 228 (1st Cir. 1973).

17. Make sure that all of the individuals who are subject to the duty of disclosure, such as spelled out in 37 CFR 1.56, are informed of and fulfill their duty.

18. Finally, if information was specifically considered and discarded as not material, this fact might be recorded in an attorney's file or applicant's file, including the reason for discarding it. If judgment might have been bad or something might have been overlooked inadvertently, a note made at the time of evaluation might be an invaluable aid in explaining that the mistake was honest and excusable. Though such records are not required, they could be helpful in recalling and explaining actions in the event of a question of "fraud" or "inequitable conduct" raised at a later time.

## 2005 Comparison to Requirement for Information

Under 37 CFR 1.56, each individual associated with the filing and prosecution of a patent application has a duty to disclose on his or her own initiative information material to patentability under 37 CFR 1.56. By contrast, under 37 CFR 1.105, an examiner or other Office employee is authorized to require, from parties identified in 37 CFR 1.56, information reasonably necessary to examine or treat a matter in an application. The provisions of 37 CFR 1.105 are detailed in MPEP § 704 *et seq.* The criteria for requiring information under 37 CFR 1.56, i.e., materiality to the patentability of claimed subject matter, is substantially higher than the criteria for requiring information under 37 CFR 1.105, i.e., reasonable necessity to the examination of the application. Thus, information required by the examiner pursuant to 37 CFR 1.105 would not necessarily be considered material to patentability in itself, but would be necessary to obtain a complete record from which a determination of patentability will be made.

# **EXHIBIT 6**

*Docket No.: 6259P002C*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

PRADEEP J. IYER, ET AL.

Application No.:

Filed: June 29, 2005

For: **A System and Method for Monitoring and  
Enforcing Policy Within a Wireless  
Network**

Art Group: 2683

Examiner: Stephen M. D'Agosta

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. §1.97

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

In accordance with the duty of disclosure, enclosed is a copy of IDS Citation Form PTO/SB/08 or PTO-1449, together with copies of the documents cited on that form, except for copies not required to be submitted (e.g., copies of U.S. patents and U.S. published patent applications need not be enclosed), which are being submitted concurrently with the Continuation Application. It is respectfully requested that the cited references be considered and that the enclosed copy of PTO/SB/08 be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s). Some or all of the references listed on the enclosed PTO/SB/08 were previously identified in the parent application (Application No. 10/254,125, filed September 24, 2002) and copies of the references were furnished at that time. Accordingly, per 37 CFR §1.98(d)(1) additional copies of those references are not submitted herewith.

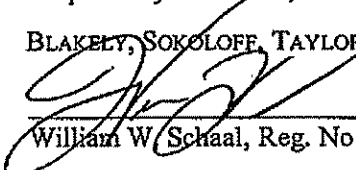
The submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made in the subject application and is not to be construed as an admission that the information cited in this statement is material to patentability.

Please charge any fees due to Deposit Account 02-2666. A duplicate copy of the Fee Transmittal (PTO/SB/17) is enclosed for this purpose.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: June 29, 2005



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William W. Schaal, Reg. No. 39,018

12400 Wilshire Boulevard, 7th Floor  
Los Angeles, CA 90025  
Telephone: (714) 557-3800



Substitute for form 1449A/PTO				<b>Complete if Known</b>	
<b>INFORMATION DISCLOSURE</b> <b>STATEMENT BY APPLICANT</b> <i>(use as many sheets as necessary)</i>				Application Number	
				Filing Date	
				First Named Inventor	
				Art Unit	
				Examiner Name	
Sheet 1 of 1				Attorney Docket Number 6259P002C	

U.S. PATENT DOCUMENTS						
Examiner Initials*	Cite No.*	Document Number	Publication Date or Issue Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	
		Number - Kind Code* (If known)				
		US-2002/0069278 A1	06-06-2002	Forslow		
		US-2002/0099503 A1	07-25-2002	Mishra		
		US-2002/0159418 A1	10-31-2002	Rudnick, et al.		
		US-6,493,698	12-10-2002	Beylin		
		US-2003/0018760 A1	01-23-2003	Putzolu, et al.		
		US-2003/0023711 A1	01-30-2003	Parmar, et al.		
		US-2003/0017826 A1	01-23-2003	Fishman, et al.		
		US-2003/0031151 A1	02-13-2003	Sharma, et al.		
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FOREIGN PATENT DOCUMENTS						
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		Country Code* - Number* - Kind Code* (if known)				

Examiner Signature		Date Considered	
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\*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication.

\*Applicant's unique citation designation number (optional). \*See Kinds Codes of USPTO Patent Documents at [www.uspto.gov](http://www.uspto.gov) or MPEP 901.04. \*Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). \*For Japanese patent documents, the indication of the year of reign of the Emperor must precede the serial number of the patent document. \*Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 18 if possible. \*Applicant is to place a check mark here if English language translation is attached.

Based on PTO/SB/08A (08-03) as modified by Blakey, Sokoloff, Taylor & Zafman (w/2) 08/11/2003.

Send To: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

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## Assignments on the Web &gt; Patent Query

## Patent Assignment Abstract of Title

**NOTE: Results display only for issued patents and published applications. For pending or abandoned applications please consult USPTO staff.**

## Total Assignments: 2

Patent #: NONE Issue Dt: Application #: 11171913 Filing Dt: 06/29/2005  
 Publication #: 20050254474 Pub Dt: 11/17/2005  
 Inventors: Pradeep J. Iyer, Partha Narasimhan  
 Title: System and method for monitoring and enforcing policy within a wireless network

## Assignment: 1

Reel/Frame: 018605/0790 Recorded: 12/08/2006 Pages: 3

Conveyance: CHANGE OF NAME (SEE DOCUMENT FOR DETAILS).

Assignors: IYER, PRADEEP J.

Exec Dt: 09/23/2002

NARASIMHAN, PARTHA

Exec Dt: 09/23/2002

Assignee: ARUBA NETWORKS, INC.

180 GREAT OAKS BOULEVARD  
 SAN JOSE, CALIFORNIA 95119

Correspondent: WILLIAM W. SCHAAL  
 3200 PARK CENTER DRIVE  
 SUITE 700  
 COSTA MESA, CA 92626

## Assignment: 2

Reel/Frame: 018575/0608 Recorded: 12/01/2006 Pages: 6

Conveyance: CORRECTIVE ASSIGNMENT TO CORRECT THE NAME OF THE ASSIGNEE THAT WAS INCORRECTLY IDENTIFIED PREVIOUSLY  
 RECORDED ON REEL 013336 FRAME 0570. ASSIGNOR(S) HEREBY CONFIRMS THE ASSIGNMENT TO ARUBA WIRELESS  
 NETWORKS, INC.,

Assignors: IYER, PRADEEP J.

Exec Dt: 09/23/2006

NARASIMHAN, PARTHA

Exec Dt: 09/23/2006

Assignee: ARUBA WIRELESS NETWORKS, INC.

180 GREAT OAKS BOULEVARD  
 SAN JOSE, CALIFORNIA 95119

Correspondent: WILLIAM W. SCHAAL  
 3200 PARK CENTER DRIVE  
 SUITE 700  
 COSTA MESA, CA 92626

If you have any comments or questions concerning the data displayed, contact PRD / Assignments at 571-272-3350. v.2.0.1  
 Search Results as of: 12/05/2007 02:14 PM  
 Web interface last modified: April 20, 2007 v.2.0.1

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